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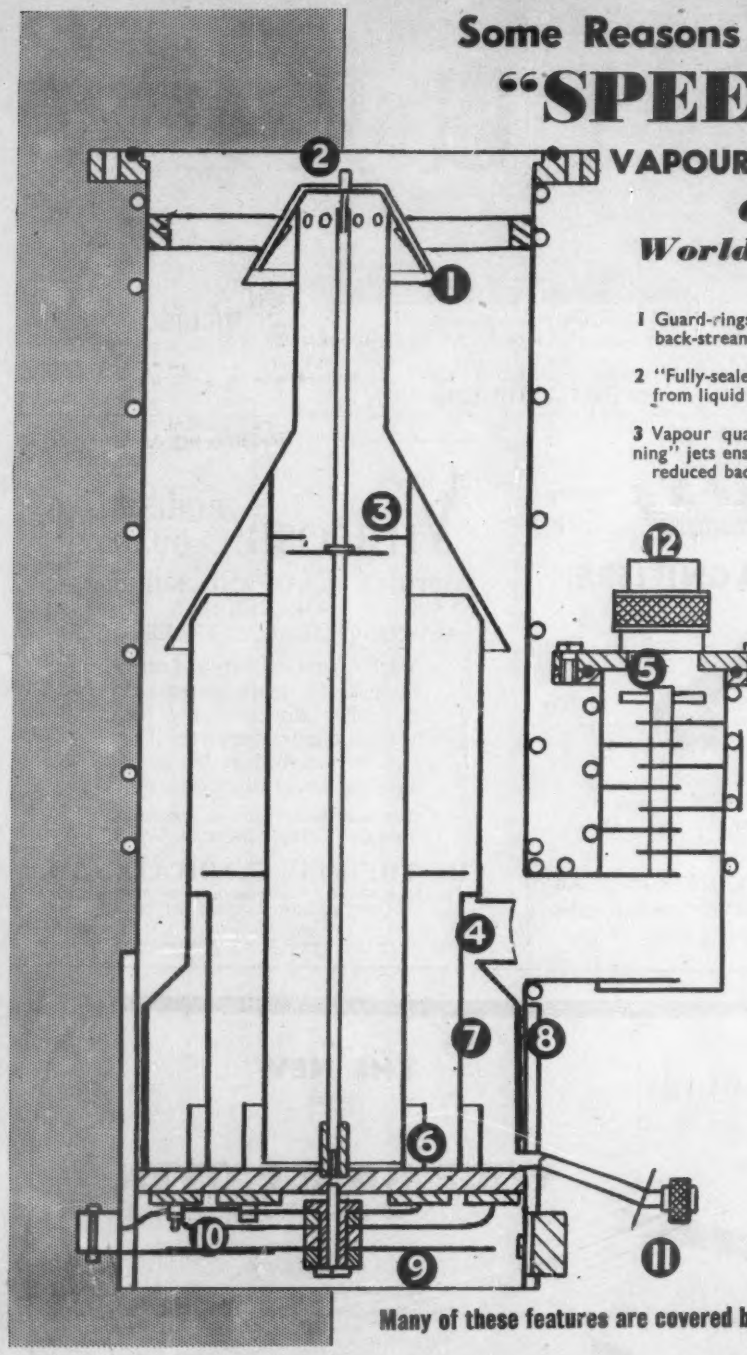

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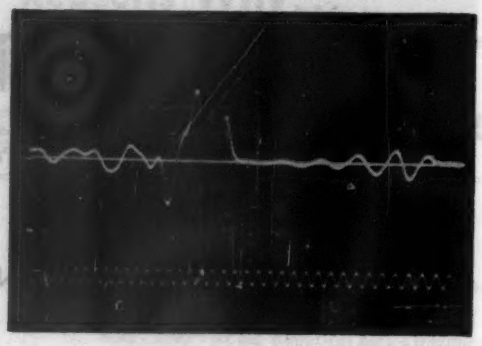

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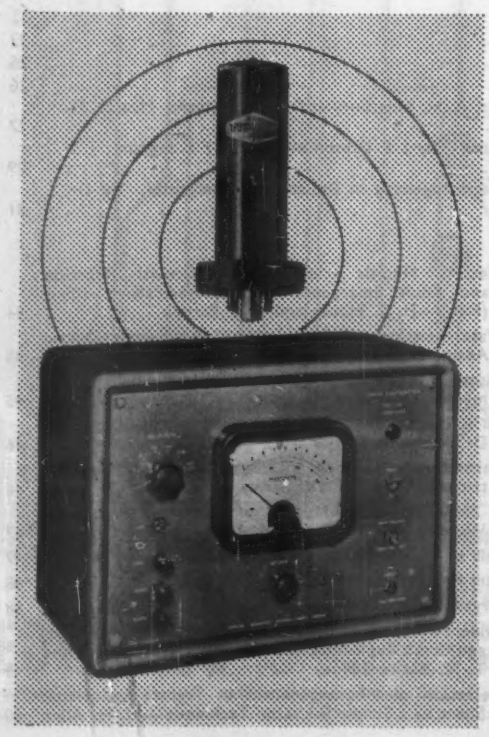

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THE CASE FOR SCIENCE GREATS

OUR intellectual disciplines are drifting apart, leaving at the centre only a void that lays bare a fundamental weakness in our present-day civilization. In this situation, a key position is held by the universities, for, even if unwittingly, they determine what is taught in the schools; while they give to students much of the knowledge, and do a great deal to mould the sense of values and the thinking which they as graduates carry into public life.

Yet, at the universities, the various disciplines are becoming more and more vocational. At high pressure, men and women are being turned out who are experts in some particular field—lawyers, doctors, biochemists, engineers, geologists, teachers of modern languages, and specialists in European history. But the universities are doing very little to prepare their students to cope with the personal problems they will meet in everyday life; still less are they training them to take an active part in the affairs of the community and of the whole association of nations.

More than that, young people who are undecided about what they would like to do later, or who intend to embark upon some career that requires general and not professional training, are steadily being squeezed out. In other words, the universities are gradually renouncing what most people would still hold to be their primary function, which is not the production of various types of intellectual technicians, however essential they may be, but of people who at the highest level will be the true leaders of the nation, and indeed, of all humanity. Similar situations appear to be developing in various parts of the world.

Conditions were different in the past. The medieval schools of theology and philosophy occupied the central position where now there is a void; they were in close touch with the intellectual life of the nation, and they attracted the keenest minds. This tradition was taken over by the school of Classical Greats, at Oxford, as it grew up during the nineteenth century. That school has served as a magnificent inspiration to a number of highly gifted men who have made their mark in such fields as politics, the Church, education, and the higher Civil Service. But with its eyes turned to the riches of Greek and Roman literature, art and philosophy, it has been losing ground in recent years, while that of Modern Greats, based on the study of philosophy, politics and economics, has not fully taken its place.

The reason for this is easy to see. Even in Modern Greats the outlook is academic and bookish; the course fails to take count of developments in modern science, a force that is now transforming the world at an ever-increasing pace. It is often argued that science operates only with material things, yet its applications, repercussions and implications affect every aspect of civilization, whether they be economic, political, social, ethical, philosophical, or finally, spiritual. All these aspects, for example, are involved in the development of atomic physics, in mass-communications based on electronics, in the use of vaccination against poliomyelitis, and in the treatment of delinquents.

It is of the highest importance that every effort should be made to come to terms with science in all these various aspects, at the highest level, where its impact on civilization may be comprehended as a whole. That is something that the present departments of science, immersed as they are in their own sectional interests, cannot possibly undertake. What is needed is the institution of an entirely new discipline, which might take the form of Science Greats.

One can readily suggest some of the elements that ought to go to make up such a school. One would be the exact sciences, and their technological applications—for the applications of science are as important as pure theory. Another would be the life sciences; for while, apart from biology, they are still at a low level of development, they are rich in insights that penetrate to the personal relationships, impulses, motives and ideals by which men live. A third essential element would be history, but in its interpretation of the past it should make use of those insights we have just mentioned, for one cannot come to terms with the present world solely with the intellectual equipment of the past.

A fourth element should be philosophy. Education is sterile unless running through it is a coherent philosophical system and a goal; and it needs the driving-force of moral purpose. In this sense, our modern schools of philosophy are anæmic ghosts as compared with some of the great founts of wisdom and inspiration in the past. They have lost the urgency of a social purpose. Yet science presents enormous ever-expanding fields rich in philosophical implications, such as the light it is now throwing on the nature of matter and energy, on the origin of life, and on the question of responsibility in anti-social behaviour.

The goal of such a school should be the welfare of man—his material welfare, but also what is indissolubly bound up with it, his social welfare, together with his moral and spiritual good. The ideals of truth, goodness and beauty, which now have such a hollow ring in many university departments, could then be brought back into the domains where they belong, although in modern dress, in keeping with present-day requirements.

Above all, a school of Science Greats would differ from the corresponding ones of the past in drawing new ideas directly from research—not the painstaking searching of bygone texts for facts and interpretations that other readers have missed, but the *experimental* research which is the breath of science, and in which the outcome cannot be predicted. The spirit of that kind of research should permeate all its activities, and in the same way, research would need to be applied in the shaping of its future policies.

Similarly, its outlook should at all times be realistic and practical, not merely bookish and academic. The students would learn a great deal if they could see at first hand something of modern research in progress and finding application in industrial processes; if they could talk about the realities of life with housewives and trade union officials; if they could discuss philosophy with probation officers and biochemists.

Mention of these requirements leads to the question of the actual content of the teaching course. The supply of available factual matter and related principle is enormous, and far beyond the powers of comprehension of even the most gifted students. At the same time, the contention that the course would amount to nothing more than a jumbled smattering of disconnected subjects would need to be squarely faced. The syllabus would have to be highly selective, concentrating on the contributions of each of the separate disciplines which in the context of the school would be thought to be most representative and significant.

The necessity for selection would present the teaching staff with a problem that is central to the understanding of the place of science in the modern world; and the fact that they would be compelled to give it consideration would be one of the primary consequences of the establishment of a school in Science Greats. At present, this problem is being given thought only on an individualistic basis; within the school it would become a matter of continuing group discussion in circumstances favourable to its deeper comprehension and to the spread of attitudes that deeper comprehension would tend to generate. For the other university disciplines and for the nation as a whole that would be all to the good.

What students would wish to take Science Greats? In response to this question, one thinks of the men and women whose ambition it is to take an active part in public affairs, in politics, international relations, the diplomatic and consular service, in local government, social and welfare movements, and in the higher Civil Service. In addition, there are now many people holding executive positions in industry and commerce who do not require specialized professional training, but who badly need a conspectus of the world as a going concern in all the various aspects. Are they to be squeezed out of the universities and be made to feel uncomfortable at the grammar schools, above ordinary level? That is why, with suitable adaptations, one hopes that the supply of students would be large enough to justify the establishment of schools of Science Greats in British universities.

An interesting move in this direction is the recent suggestion put forward by the General Board of the Faculties of the University of Cambridge for a new Tripos examination. The proposals, which involve a two-year course in Arts subjects, followed by a special course in either the biological or physical sciences, cannot be discussed here. They show, however, that university circles in Britain are aware of the problems of fitting students for life in the modern world, and are prepared to consider ways of meeting them.

ADVANCES IN NUCLEAR PHYSICS

Progress in Nuclear Physics

Vol. 5. Edited by Prof. O. R. Frisch. (Progress Series.) Pp. vii+325. (London and New York: Pergamon Press, Ltd., 1956.) 80*s*. net; 12.50 dollars.

THE fifth volume of O. R. Frisch's well-established series has appeared, containing seven authoritative articles on topics of current interest. The articles are on the determination of nuclear reaction energies by deflexion measurements, by W. W. Buechner; the inelastic scattering of fast neutrons, by Joan M. Freeman; new electronic techniques for the nuclear physicist, by K. Kandiah and G. B. C. Chaplin; the bubble chamber, by C. Dodd; the radius of a nucleus, by J. M. C. Scott; the neutrino, by B. W. Ridley; and organic scintillators, by F. D. Brooks. As in the previous volumes, the main emphasis is on experimental physics and several of the articles are devoted to experimental techniques. Scott's article on nuclear radii is the only one which gives a specifically theoretical treatment.

Two of the articles are concerned with 'low-energy' nuclear physics. Buechner reviews the ion optics of modern methods of producing mono-energetic beams and of analysing the charged reaction products, and discusses resolution, solid angle of acceptance, and calibration of the various electrostatic and magnetic systems employed in this specialized field, of which he is one of the principal exponents. Miss Freeman writes on a subject in which work of high precision is experimentally difficult, but which not only is important for nuclear spectroscopy but also has a practical bearing on the design of nuclear reactors. She reviews the experimental methods and results for the various inelastic processes which occur in fast neutron bombardment, and follows with a theoretical discussion.

Ridley's article on the neutrino is made topical by two events which occurred after it was written, namely, the discovery of free neutrinos and the excitement about the non-conservation of parity. He discusses the neutrino hypothesis in relation to beta-decay, K-capture, and meson and heavy meson decay, and reviews the experiments which have been performed and the theoretical background.

Scott gives a theoretical discussion of nuclear radii as determined by electrical methods, in which the charge distribution may in principle be obtained (mesic X-rays, electron scattering, isotope shift of atomic spectra, X-ray shift), considerations of the coulomb energy of nuclei (mirror nuclei and empirical formulae), and methods depending on nuclear forces (nucleon-nuclear collision cross-sections and barrier penetration). He concludes that the nuclear force radii are not, after all, much greater than the electrical radii when the finite range of nuclear forces is taken into account.

The remaining three articles are concerned with experimental techniques; a proportion of three out of seven is very reasonable in a series which has concerned itself mainly with experimental nuclear physics—major advances have been made in a diverse range of techniques, and further advances will be necessary if full advantage is to be taken of the new large accelerators. Kandiah and Chaplin present some recent developments in electronics, particularly in fast circuits and in simplified scaling systems. Appropriately, half the article is devoted to the transistor as a circuit element. Dodd

reviews the progress of bubble chamber development; this elegant technique has been developed into an instrument of great power for high-energy physics, and is entering the realm of heavy engineering with the 72-in. chamber at Berkeley, California. However, commensurate effort is needed, and is beginning to be applied, on the problem of evaluating the mass of visual data produced with the bubble chamber, if the necessary good statistics are to be obtained; Dodd's article does not review this problem. Brooks discusses the present state of knowledge of the mechanism of scintillation in organic materials, and reviews recent data on the properties of organic scintillators—including liquid and plastic scintillators.

The authors have again maintained the high standard set by previous volumes in the series, and again they are all active workers in the fields which they discuss. As usual the quality of production is excellent, but this time there has been a longer delay in publication. The articles do not set out to be exhaustive, but are intended for specialists in related fields. The same characteristic is evident in the choice of topics in the whole series so far; no attempt is made to give frequent up-to-the-minute progress reports on all aspects of nuclear physics. In this way it has been possible to select topics in which a certain degree of stability has been reached, and the policy has been successful since the articles have not rapidly become out of date. However, rather few articles have so far been devoted to experiments in high-energy physics, in which much solid progress has been made during the past few years; perhaps we may see one or more articles on this important subject in the next volume.

T. G. PICKAVANCE

A COMMUNITY OF PENGUINS

A Population Study of Penguins

By L. E. Richdale. Pp. iii+195+2 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 42*s*. net.

THIS book is the record of part of a most careful and painstaking field research extending over nearly a score of years on the penguins of New Zealand. The studies described here mainly concern the yellow-eyed penguin, *Megadyptes antipodes*, a non-migratory species that is resident in the south-east of New Zealand and some of the adjacent islands; the colonies situated on the Otago peninsula where the author worked lie at the extreme north of the breeding range. None of the breeding areas studied lies more than twenty miles from the city of Dunedin where the author lives, and consequently he was able to visit them 1,318 times in the course of his work.

The observations recorded and analysed in this research were made chiefly on just over 400 birds divided almost equally between the sexes, and the results of 819 separate matings during eighteen seasons are traced. "The history of the individual resident penguins was well known to me. Sometimes the acquaintance lasted only one season, after which the penguin disappeared, but five birds were still present in 1953–54, seventeen seasons after they were first found." Recognition of the birds, of course, meant that it was necessary to mark them; "all adults and juveniles when first met were banded and footmarked, the latter device making it impossible to lose the identity of the bird should a band come off". But it is astonishing to read that when the author started his work in 1936 he was "unaware that wild birds were being banded in America and Europe", and that inquiries from "authorities in New Zealand" on how to band or mark wild birds led to nothing. The bands he eventually obtained from Europe were unsatisfactory and so, since the end of 1938, he has made his own although it takes fifteen minutes to manufacture each one. Mr. Richdale analyses and discusses the results of his field work with equal patience and care, and presents the most complete account of the population dynamics that has yet appeared about any species of penguin.

The author found that there was considerable wandering during the first five years of the birds' lives, but after that the penguins rarely adopted a new breeding place. Linked with this is the length of the pair-bond; there is a high rate of dissolution in youth, and in addition some older birds are unable to retain their mates because of incompatibility and the pressure of intra-sexual competition. "Once this period of instability is passed, 63 per cent of the pair-bonds on the average tend to remain intact in a succeeding season." It is not easy to sex living penguins, but one bird that was accidentally killed was dissected and, "because Yellow-eyed Penguins change their mates frequently it was possible by means of this one known bird to trace accurately the sex of every penguin that lived in that particular breeding area in the research period, both before and after the death of the bird".

As a result of his work the author was able to assess the precise composition of a penguin community and the proportions of juveniles, non-breeders and breeders, with, in many cases, their blood-relationship to each other, and the sex-ratio. Among many other matters, he also discusses the influence of age and other factors on breeding success, and the survival and mortality rates of juveniles and adults. A valuable chapter gives a detailed account of the process of moulting and compares that of the yellow-eyed penguin with what is known of the phenomenon in other species of penguin.

The book is produced according to the standards expected of the Press from which it comes and worthily presents an important contribution to ornithology.

L. HARRISON MATTHEWS

SOIL IMPROVEMENT AND BETTER CROPS

Soil Fertility and Fertilizers

By Samuel L. Tisdale and Werner L. Nelson. Pp. xxii+430. (New York and London: The Macmillan Company, 1956.) 45*s*. net.

Farm Soils

Their Fertilization and Management. By Prof. Edmund L. Worthen and Prof. Samuel R. Aldrich. Fifth edition. (Wiley Farm Series.) Pp. viii+439+5 plates. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 40*s*. net.

THE book by Tisdale and Nelson is essentially a product of North Carolina State College, which has a deservedly high reputation for its studies in plant nutrition and for its State advisory soil service. It is a presentation, for the student of soil fertility, of the fundamental principles of the subject, sup-

ported by a selection of experimental results. The text follows the usual sequence of historical introduction, a series of chapters on the factors affecting plant growth and the part played by those elements essential in plant nutrition, the sources and manufacture of the range of compounds used in soil amelioration and fertilization, the evaluation of fertility and the best practices in sound soil management.

There is little of a controversial character in the book, for its contents are a balanced and a clearly written exposition of up-to-date knowledge. For example, fertilizer recommendations are based on soil tests, about which much more space is given to the principles of the methods and the interpretation of the results than to details of technique; the trace elements are adequately dealt with—although a little more information on the use of complexing agents might have been included—but not without arguments against their indiscriminate use; the rapid development of more concentrated fertilizer compounds is discussed and the dangers of leaving out sulphates in the process; there are full descriptions of the various methods of applying fertilizers, of salt effects, of the recovery of the nutrients in the crop, and of the fixation of potassium and phosphates and the changes undergone by soil nitrogen.

The conditions described are, of course, those found in the United States, and numerous data are provided to illustrate the trend of crop yields obtained by exploitation and conservation and the improvements of soils by management aimed at producing high yields. In this connexion it is interesting to record that in 1955, 25 per cent of crop production was attributable to fertilizers, that the bigger responses were obtained on the poorer soils, and that outstanding returns came from liming.

The very comprehensive table of contents is a particularly good feature for reference purposes, and it is a pleasure to see a proper chemical nomenclature displace the archaic terms of the fertilizer trade. The book is extremely well produced, and with its vast amount of useful information, will undoubtedly appeal to a wide range of people concerned with crop production.

However, the most urgent type of instruction, to the farmer who cannot be expected to master the background and vocabularies of the various sciences, is the distillation, in his own language, of the manners and techniques of the many new developments of recent years, and the book by Worthen and Aldrich, of Cornell University, one of the Wiley Farm Series, is a praiseworthy effort to put the subject of soils into a form that is quite comprehensible to anyone interested in soils, however little he knows of geology and chemistry. The emphasis is on the principles of soil management, coupled with that kind of information helpful for appreciating and applying recommendations from whatever source, and although the text has been prepared with an eye particularly on conditions in the north-east of the United States, there is something for nearly all farmers.

The book begins with a general description of soils and the parts played by parent material and climate; it ends with chapters on soil maps, the zonal types and classification. The bulk of the text, however, is concerned with the handling and improvement of the soil and the best rotations for maintaining fertility. The measures required to control excess water and erosion, and to overcome water deficiency, are dealt with, and there is constant reference to tilth. The pronouncements on fertilizers, crop residues and farmyard manure are forthright, and this leads on occasion to over-simplification, but without serious sacrifice of scientific accuracy. The purist may shudder at the style of expression in places, but the American farmer, to whom the book is addressed, may not be troubled by such considerations. There are a very large number of photographs, tables and simple diagrams, a glossary and what appears to be a very full index, and the editing and printing are beyond reproach.

A. M. Smith

DYNAMICS OF DIVORCE

Neurotic Interaction in Marriage

Edited by Victor W. Eisenstein. Pp. xv+352. (London: Tavistock Publications, Ltd., 1956.) 30*s*. net.

It is usually obvious that a person's reactions to a situation are dependent on how that situation has been met before. Thus, if a child is bitten by the first dog it tries to stroke, its behaviour when it encounters dogs in later life will be influenced by this first experience. It will behave differently from the child who found its first dog affectionate. Although most people are willing to accept this from daily observation, they are often unwilling to extend it to more complex matters; as, for example, the child's reaction to people in later life being dependent on the behaviour of its father and mother. Yet these are usually the first human beings of whom it has intimate experience.

It has been found that the behaviour of the partners in marriage demonstrates the same mechanism. The husband unconsciously treats his wife as he learned to treat his mother, and the wife unconsciously behaves to the husband as her father taught her to behave to him. That such reactions can bring tension into the intimate contacts of marriage is only too obvious. The advent of children further confuses the issue.

This book is really a collection of studies by various American authorities on the dynamics of family life. It gives a valuable picture of the causes of marital distress, and the authors have had great experience in treating them. Suggestions for future research are also given.

It is impossible to describe every section at length but it is all well worth reading. Outstanding chapters are those by Mahler and Rabinovitch on "The Effects of Marital Conflict on Child Development", and by Eidelberg on "Neurotic Choice of Mate"; that by Mittelman on "Analysis of Reciprocal Neurotic Patterns in Family Relationships" is most interesting. The more difficult, and in some cases insoluble, problems are dealt with in the chapters on "Interaction between Psychotic Partners", by Jacobson and Byehowski, and "The Alcoholic Spouse" by Fox. As well as chapters on individual analysis, there are descriptions of what the Americans call 'casework' (which is more or less educational counselling) and group therapy. The application of the Rorschach tests to the partners in unstable marriages is an interesting development, and it seems that the Americans are working at research in the avoidance of grossly unsuitable marriages in the future. Anyone who deals with marriage, at least from the point of view of guidance, and therapy for marriages which are breaking should most certainly read this book.

It is usual to state piously that the stability of the nation depends on the family, but this is much truer

than is usually understood. The stability of such organizations as the Army, church, and even trades unions, is only a reflexion of the family constellation, and this is exemplified by such terms as 'brother officers' and the use of the appellations 'father' and 'brother' in church and trades unions. The respect for authority and the manner in which we regard the State are only projections of our feelings derived from the family.

We spend a tremendous amount of money, both directly and indirectly, on broken marriages, divorce and their consequences: delinquency, neurosis, and, in some cases, psychosis. We cannot know too much about the nature of marriage and why it breaks down. The book is well written, with a good index, and none of the authors breaks out in the too blatant Americanisms which distract and annoy the British reader.

CLIFFORD ALLEN

CHEMICAL BASIS OF BLOOD GROUP SPECIFICITY

Blood Group Substances

Their Chemistry and Immunochemistry. By Elvin A. Kabat. Pp. ix+330. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8 dollars.

THE greatly increased use of blood transfusion in medical practice during the past two decades has led to a rapid expansion in our knowledge of human blood-groups, and nine independent systems have been identified by serological methods. An understanding of the chemical basis of blood-group specificity has, however, lagged far behind the serological discoveries and even now it is not possible to assign a detailed chemical structure to any one blood group substance, or to define completely the smaller structural units within the complex macromolecules which confer on them their characteristic serological properties. Much progress towards this goal has nevertheless been achieved, and the present book by Elvin Kabat represents the first attempt to bring together all the existing information on the chemistry and immunochemistry of the blood group substances.

Isolation of the materials responsible for blood-group specificity from the red cell surface presents considerable technical difficulties and for this reason investigations on the chemical nature of the blood group substances have been almost entirely restricted to those group-specific materials which also occur in tissue fluids and secretions in a water-soluble form, that is, to the A, B, O(H) and Lewis (Le^a) substances. The major part of the book is devoted to a comprehensive survey of the methods used for the isolation, purification and chemical and immunochemical analyses of these water-soluble mucopolysaccharides. The author's own outstanding contribution to the immunochemistry of blood group substances has been the application to them of the quantitative precipitin technique developed by Heidelberger and his co-workers for the quantitative measurement of antigens, antibodies and complement, and the emphasis throughout the book is on this approach to blood group studies. Not all readers will agree with the author's low estimate of the value of results obtained by the hæmagglutination technique, which, although admittedly less precise, has a greater sensitivity than the precipitin method. Indeed the first indications of the simple structures responsible for specificity in both A and H substances were obtained by means of hæmagglutination inhibition experiments. The amount of experimental detail included seems rather excessive in some parts of the text and many of the long tables, which have been taken unchanged from the original papers, could with advantage have been given in a summarized form. The author has, however, reviewed the field with admirable thoroughness, the presentation is accurate and systematic and each chapter contains an extensive list of references.

This is essentially a book for the specialist and little concession is made to the general reader. It should nevertheless prove invaluable as an introduction for those entering the field of chemical studies on blood-group substances and as a reference book for immunochemists and biochemical geneticists interested in these serologically active mucopolysaccharide materials which are such excellent 'markers' in the field of human genetics.

WINIFRED M. WATKINS

LIGHT-SCATTERING AND MACROMOLECULAR CHEMISTRY

Light-Scattering in Physical Chemistry

By Dr. K. A. Stacey. Pp. viii+226. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 40*s*.

IN 1944 Debye showed that the molecular weight and dimensions of a polymer in solution can be determined by the light-scattering technique. Since then a large number of papers on the application of this method to the study of macromolecules have appeared, and it is becoming increasingly popular as a routine technique for determining the weight-average molecular weights of polymers. Dr. Stacey is the first worker to devote an entire book to a survey of this new and important field, and in doing so he makes a timely contribution to the existing literature.

The book falls roughly into two equal parts, one dealing with the theory and practice of light-scattering relevant to this particular application, and the other with its use in the study of macromolecules. The first part is prefaced by a summary of the various methods for determining molecular weights of large molecules, and then the theory of light-scattering is developed in a way which emphasizes clearly the underlying principles. There is, however, a tendency to include short summaries of a large number of specific extensions of the theory when a more careful selection of the material would have allowed an improved presentation of the most important contributions. This half of the book is concluded by a very useful account of modern experimental methods. The remaining chapters are reserved for a review of the applications of this method in high polymer, protein and polyelectrolyte chemistry. Here again a large number of papers have been summarized, but little attempt is made to correlate or appraise the various contributions.

The author maintains that the time is not ripe for an authoritative monograph, but one feels that a more critical assessment of the present status of the light-scattering technique is required. The book does, however, contain some five hundred references to original papers published prior to 1956 and it will be of considerable value to anyone connected with the field.

G. ALLEN

An Introduction to Modern Organic Analysis

By Sidney Siggia and Hans J. Stolten. Pp. vii+250. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 4.50 dollars.

MOST modern books on analysis are necessarily specialized. They deal with only one type of approach to the problem and describe in detail the application of one technique or group of associated techniques. This excellent book, on the other hand, surveys the whole field of organic analysis and introduces the reader to the general strategy of the investigation of organic materials, discussing a few particular examples by way of illustration. Full working details are not, in general, provided, but at the end of each chapter one or two standard works and references are listed, from which the reader may obtain the necessary tactical details.

In successive chapters the principles and application of various methods of attack are described: elementary analysis; the determination of functional groups; potentiometric titration; absorption spectroscopy in the visible, ultra-violet and infra-red regions; polarography and X-ray diffraction. Analytical uses of freezing-point, refractive index and density are discussed. Various methods for separating mixtures are reviewed, including chromatography and ion-exchange, and brief mention is made of a number of more specialized devices. Although most of these subjects are dealt with very concisely, the sections on group analysis and on absorption spectrometry are particularly well done.

This volume was based on lectures to adult audiences and is not designed as a conventional student's text-book, yet it provides a most interesting and readable general introduction to the subject which should be of great value to graduates about to begin work as responsible technologists. It conveys a feeling of contact with real practical problems which is very stimulating. The book is well produced and illustrated and has an adequate index. It is remarkably good value for its moderate price.

G. M. Bennett

Encyclopedia of Chemical Reactions

Compiled by Prof. C. A. Jacobson. Edited by Clifford A. Hampel. Vol. 6: Samarium; Scandium; Selenium; Silicon; Silver; Sodium. Pp. vii+438. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 100*s*. net.

THIS encyclopedia of chemical reactions is based upon reactions abstracted by some 100 abstractors from technical and scientific periodicals. The abstractors worked under the direction of Dr. C. A. Jacobson, lately professor of chemistry in the University of West Virginia, who had as his target a compilation of chemical reactions involving inorganic reagents. This volume deals with reactions involving samarium, scandium, selenium, silicon, silver and sodium. The information is very concise as the following example indicates. "Electricity makes silver react with carbon dioxide, forming silver oxide and carbon monoxide. $2Ag + CO_2 \rightarrow Ag_2O + CO$." The reference is W. R. Grove, *Phil. Trans. Roy. Soc.* (*London*), 142, 94; 1852. Under the heading of sodium chloride on p. 273 an abstract informs the reader "Silver nitrate is added to the solution to precipitate any soluble chloride, as is well known, as silver chloride. Sodium is used as an example and the corresponding nitrate is also formed. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$". The reference is W. Crookes, *Phil. Trans. Roy. Soc.* (*London*), 174, 897; 1883. It would be unfair to leave the impression that the information is all of this vintage, but it is very doubtful whether these abstracts are worth the 100*s*. which is the price of this volume. The best advice for the prospective buyer is to see the volume before purchasing it.

W. Wardlaw

Crystallographic Data for the Calcium Silicates

By Dr. L. Heller and Dr. H. F. W. Taylor. Pp. vi+79. (London: H.M. Stationery Office, 1956. Published for the Department of Scientific and Industrial Research.) 10*s*. 6*d*. net.

THIS little book summarizes the results of a programme of research into the hydration products of cement sponsored by the Building Research Board. Almost all the known natural calcium silicates and a very wide range of artificial products were examined, and for each well-defined phase the authors give, so far as possible: X-ray powder data, optical properties, density, crystal-structure data, natural and technical occurrence, and short details of synthesis. The data appear to be carefully collected and checked, and the book should be a very useful summary for workers dealing with cement or boiler scales or with the calcium silicate minerals. In two appendixes a classification of the hydrated calcium silicates is attempted, with notes on their dehydration and on the structure types known in the group. A third appendix lists the spacings and intensities of the three strongest lines in the X-ray powder photographs of the phases described. The worst defect of the book is the lack of an index; in its absence, workers desiring to find out what is known of such 'doubtful minerals' as reyerite (p. 28), or the meaning of such old names as alite (p. 19), will probably fail to locate the information.

M. H. Hey

Table of the Fresnel Integral to Six Decimal Places

Compiled by T. Pearcey. Pp. 63. (Cambridge: At the University Press, 1956.) 12*s*. 6*d*. net.

THE Fresnel integral occurs in the solutions of a large number of diffraction problems, and it also frequently arises in other problems of theoretical physics. Despite the increasing availability of electronic computors, there is still a need for good tables of many functions; for often only relatively few numerical results are required, such as would not justify the expense of programming. Again, even when a calculation has been programmed, it is useful to check this by means of a desk machine computation. The present table gives:

$$C(u) = \int_0^u \cos \frac{\pi t^2}{2} dt, \quad S(u) = \int_0^u \sin \frac{\pi t^2}{2} dt$$

employing as the argument $x = \pi u^2/2$ — the definition of $S(u)$ on page 8 gives x, in error, as the upper limit. The use of x as the variable in place of u makes linear interpolation possible throughout most of the table, but it has the disadvantage that $x = 50{\cdot}00$, the final entry, corresponds to only $u = 5{\cdot}64$, so that beyond this relatively small value other tables or asymptotic series must be used. Between $x = 0{\cdot}00$ and $1{\cdot}00$ the entries are to seven places, and to six for the region $x = 1{\cdot}00$ to $50{\cdot}00$. Second differences are given throughout, together with a small table to facilitate their use. The table is clearly set out and very easy to use.

H. H. Hopkins

THE INTERNATIONAL GEOPHYSICAL YEAR

By Dr. M. NICOLET
Secrétaire Général, Comité Spécial de l'Année Géophysique Internationale

ALTHOUGH the programme for the International Geophysical Year has been defined during meetings of the Special Committee of the International Geophysical Year, the ultimate responsibility for the completion of this extensive programme rests with the individual National Committees for the International Geophysical Year. There are two other factors that will control the course of events during the International Geophysical Year: first, the geographical conditions, which are one important element determining the nature of the essential observations; and secondly, the solar conditions, which will be an important factor in deciding to what extent the definitive programme can be carried through.

The programme of geophysical observations to be undertaken during the period July 1957–December 1958 is concerned with fourteen different disciplines. These can be considered in three main groups. The first group, which consists of geomagnetism, aurora and airglow, ionosphere and cosmic rays, requires continual solar observations and uses the most modern techniques, including rockets and earth satellites. It involves simultaneous synoptic observation for morphological studies and special observations to determine physical parameters at present unknown. In the sphere of morphological studies the stations of the first group will be distributed over the entire surface of the globe. This is why the distribution is based primarily upon a meridional distribution when following continents, and upon a latitudinal distribution for the arctic and antarctic regions, and the equatorial belt. These diverse disciplines concern phenomena depending on the geomagnetic field. For this reason the geographical possibilities are not necessarily the basis of the distribution of the observatories. In particular, auroral stations are to be found mainly in the zones where there is the greatest possible chance of observing auroras and where technical methods are more developed.

The second group involves meteorology, in which the network of stations has been developed with the view of obtaining a synoptic view of atmospheric phenomena in the lower atmosphere on a world-wide scale. Thus the meteorological system is spread out over the most distant regions in order to obtain for the first time observations covering the whole of the world.

The third group is composed of the rest of the various disciplines which are brought together in the International Geophysical Year in accordance with the most urgent and diverse interests. Thus the measurement of longitudes can assist with the analysis of radio-communications. The observations made in this group will be generally associated with the existence of modern astronomical observatories. Gravity measurements have been specially introduced with the view of obtaining measurements from regions not yet fully explored; and similarly for seismology, except that the programme is larger for this subject. Oceanography obviously has its own particular problems, and has been included in the general programme for co-ordinated study, but on a much larger scale than ever before. In this case the contributions of the National Committees are, of course, totally dependent upon whether the National Committee concerned belongs to a maritime or non-maritime nation.

One subject which has only recently been added to the general programme is the measurement of nuclear radiation. This will include measurements of both natural and artificial radioactivity of samples of air, precipitation at the Earth's surface, solid particles delivered at the Earth's surface, observations of the activity of the upper air, of samples of varved ice from glaciers, and of sea water from the surface and also from various depths. It will be possible to make universal recordings of most of these types of radioactivity.

The programmes of the several National Committees will not be identical, because each contribution is dependent to a certain extent upon the geographical position and size of the country involved. At present there are more than sixty National Committees, which shows that practically every country in the world has been included. The only major exceptions are in the quadrilateral bounded by the Black Sea, the Persian Gulf, the Red Sea and the Mediterranean, where it has not been possible to make fully suitable arrangements; otherwise all the continents are covered by a network of National Committees, leaving no geographical area without an observational station.

Table 1. Meteorological Stations

Regions	Aerology	Radiation	Ozone	Atmospherics	Others
NA	116	65	11	11	17
NB	132	164	14	40	41
NC	186	148	21	26	21
CEN	84	51	6	11	5
CES	113	59	3	7	4
SC	79	69	3	5	5
SB	14	6	4	1	—
SA	26	27	0	1	8
Totals	750	579	71	102	101

Table 2. Distribution of Stations other than Meteorological

Regions	Geomagnetism	Airglow-aurora	Ionosphere	Solar activity	Cosmic rays	Longitudes and latitudes	Glaciology	Oceanography	Rocket	Seismology	Gravity
NA	46	86	49	4	17	2	26	16	3	29	18
NB	57	73	69	51	37	34	10	39	1	79	29
NC	47	40	58	41	35	23	9	61	27	83	54
CEN	25	12	33	8	12	6	—	36	5	35	8
CES	55	3	27	6	12	4	6	25	5	34	43
SC	16	10	25	8	8	8	2	45	6	46	14
SB	6	11	12	1	7	1	1	13	—	6	6
SA	24	35	18	—	8	—	30	15	—	23	19
Totals	276	270	291	119	136	78	84	250	47	335	191

Table 3. Geomagnetic Stations

NA	*a*	*b*	*c*	*d*	*e*	*f*
U.S.S.R.		2	1	8	6	13
Sweden, Finland			1	1		2
U.S.A.	6			5	4	4
Denmark		1		3		4
Canada				9	1	9
Norway				3		3
Sweden				2		2
Finland				2	1	2
Iceland				1		1
United Kingdom				1		1
	6	3	2	35	12	46

NB						
U.S.S.R.				5	4	8
Sweden				1		1
United Kingdom				3		3
Poland				4	2	4
German Fed. Rep.				3		3
German Dem. Rep.				5	2	5
Netherlands				1	1	1
Ireland				1		1
Canada				5		5
Belgium				2	1	2
Czechoslovakia				2	1	2
Austria				1		1
France				4	3	4
U.S.A.	6		1	2	3	12
Italy		1		2	1	3
Spain				1		1
Portugal					1	1
	6	1	1	42	19	57

NC						
U.S.S.R.				7	10	10
Yugoslavia				1		1
Japan				4	3	6
Italy	2	2		1		5
Bulgaria				1	1	2
Spain				5	2	5
Portugal				1	1	2
Chinese Peo. Rep.				1		1
Iran				1		1
U.S.A.				3	2	5
India				1		1
Pakistan				1		1
Egypt				2		2
France				2	1	2
Mexico				1	1	2
Rumania				1	1	1
	2	2		33	22	47

CEN						
Chinese Peo. Rep.				3		3
Pakistan				1		1
Viet Nam, Poland				1		1
India				4		4
Philippines				1	1	1
U.S.A.	2			1		3
Ethiopia				1		1
United Kingdom				1		1
Ghana				1	2	2
Colombia				1		1
Netherlands				1	1	1
France				1	1	1
Spain				1	1	1
Brazil				1		1
Bolivia	3					3
	5			19	6	25

CES	*a*	*b*	*c*	*d*	*e*	*f*
Chile					2	2
Argentine					1	1
Bolivia	34			1	1	36
Brazil					1	1
France				1	1	1
New Zealand				1		1
Peru–U.S.A.				1		1
Belgium				4	1	4
Australia				1		1
Portugal				1		1
Indonesia				1		1
Netherlands				1	1	1
United Kingdom				1		1
U.S.A.	1			1		2
India				1		1
	35			15	8	55

SC					
Argentine			4		4
Chile			3		3
Union of S. Africa		1	1		2
Australia			4		4
Portugal				1	1
New Zealand		1			1
France			1		1
		2	13	1	16

SB					
New Zealand		1	1	2	3
France			1	1	1
Union of S. Africa		1			1
Australia			1		1
		2	3	3	6

SA					
U.S.A.	1		3		4
U.S.S.R.				6	3
Argentine			5		5
New Zealand			1		1
United Kingdom			2		2
U.S.A.–New Zealand	1				1
Norway			1		1
Belgium				1	1
France			2		2
Japan			1		1
Australia			2		2
Chile			1		1
	2		18	7	24

a. Only semi-portable instrument.

b. Only storm magnetograph.

c. Only indicating equipment.

d. Magnetic station with at least normal registration of *D*-, *H*- and *Z*-components.

e. Other observations (quick-run recorder, or earth current, or rocket, etc.).

f. Total number of stations.

However, considering discipline by discipline, there are still deficiencies which in general cannot be filled for lack of men or suitable equipment. It is noteworthy that, generally speaking, it is not lack of financial means that limits the realization of certain programmes but rather the lack of suitable personnel to carry out the geophysical observations.

In a short review such as this, it is not possible to describe the contribution of each National Committee. Furthermore, during the past few months the programmes have undergone many changes due to recent technical developments. A list made in 1955 at the secretariat of the Comité Spécial de l'Année Géophysique Internationale gave the following information about the stations participating: meteorology, 559; geomagnetism, 196; aurora and airglow, 200; ionosphere, 236; solar activity, 82; cosmic rays, 100; longitudes and latitudes, 57; glaciology, 45; oceanography, 115; seismology, 70; gravity measurements, 66. To-day, at the opening of the International Geophysical Year, the number of meteorological stations is more than 1,600, and the combined total of the stations in all the other disciplines is not less than two thousand. This has

Table 4. Arctic Stations

Station	Sponsor	Geographical co-ordinates Lat.	Long.	Geomagnetic co-ordinates Lat.	Long.	Meteorology	Geomagnetism	Aurora	Ionosphere	Solar activity	Cosmic rays	Glaciology	Oceanography	Seismology	Gravity
Arctica 1	U.S.S.R.	85°–90° N.		> 70° N.		×	×	×	×						
Arctic Station "B"	U.S.A.	85° N.	100° W.	82° 21′ N.	199° 42′	×		×	×				×		×
Arctica 2	U.S.S.R.	83°–90° N.		> 70° N.		×	×	×	×						
Peary Land	Denmark	83° N.	25° W.	82° N.	140°							×			
Alert	Canada	82° 33′ N.	62° 35′ W.	85° 49′ N.	168° 31′			×	×	×					
Alert	Canada–U.S.A.	82° 30′ N.	62° 20′ W.	85° 51′ N.	167° 53′	×									×
Hazen Lake	Canada	82° N.	70° W.	86° N.	179°							×		×	×
Nord	Denmark	81° 36′ N.	16° 40′ W.	80° 50′ N.	133° 30′	×								×	
Tikhaya Bay	U.S.S.R.	80° 20′ N.	52° 48′ E.	71° 31′ N.	153° 15′	×	×	×	×		×	×		×	
Murchison Bay	Sweden, Finland, Switzerland	80° 03′ N.	18° 18′ E.	75° 15′ N.	137° 15′	×	×	×			×	×	×		
Greenland Ice Cap	Denmark–U.S.A.	60°–80° N.	30°–50° W.	80° N.	57°							×			
Eureka	Canada–U.S.A.	80° 00′ N.	85° 56′ W.	86° 31′ N.	236° 26′	×									×

been due to a considerable effort during the past year, particularly on the part of the more recently appointed National Committees.

In order to give a clear view of the distribution of effort, the world can be conveniently divided into various zones which are based on both geographical and geomagnetic position. The CSAGI regions (see Tables 1–3) are defined as follows:

NA. Arctic Region: situated to the north of the 60th geographical or geomagnetic parallel.

NB. Part of the North Subauroral Zone: between the geomagnetic parallels 45° N. and 60° N., but not including regions of higher geographical latitude than 60° N.

NC. North Minauroral Zone: between the geomagnetic parallels 20° N. and 45° N.

CEN. Areas North of the Equatorial Belt: this region extends from geomagnetic parallel 20° N. to the geomagnetic equator.

SA. Antarctic Region: to the south of the 60th geographical or geomagnetic parallel.

SB. Part of the South Subauroral Zone: between the geomagnetic parallels 45° S. and 60° S., but not including regions of higher geographical latitude than 60° S.

SC. South Minauroral Zone: between geomagnetic parallels 20° S. and 45° S.

CES. Areas South of the Equatorial Belt: this region extends from geomagnetic parallel 20° S. to the geomagnetic equator.

Table 1 shows the distribution of meteorological stations. The stations are divided into various groups: (i) aerological stations; (ii) radiation stations; (iii) stations for measuring atmospheric ozone; (iv) atmospheric stations; (v) other stations, including stations making other measurements, for example, the chemical analysis of samples for water, carbon dioxide, etc. Surface meteorological stations have not been considered because these are part of the normal framework of observations.

Table 2 gives the total number of stations in all the other disciplines; the same geographical dis-

Table 5. Antarctic Stations

Station	Sponsor	Geographical co-ordinates Lat.	Long.	Geomagnetic co-ordinates Lat.	Long.	Meteorology	Geomagnetism	Aurora	Ionosphere	Solar activity	Cosmic rays	Glaciology	Oceanography	Seismology	Gravity
Amundsen Scott	U.S.A.	90° S.		78° 30′ S.	0°	×	×	×	×			×		×	
Sovietskaya	U.S.S.R.	82° S.	50°–60° E.	80° S.	43°	×	×	×				×			
Byrd Station	U.S.A.	80° S.	120° W.	70° 36′ S.	336° 01′	×	×	×	×			×		×	×
Vostok	U.S.S.R.	78° 30′ S.	107° 00′ E.	89° 12′ S.	88° 08′	×	×	×	×			×			
Little America	U.S.A.	78° 12′ S.	162° 15′ W.	74° 08′ S.	312° 04′	×	×	×	×			×			×
General Belgrano	Argentine	77° 58′ S.	38° 48′ W.	67° 17′ S.	15° 45′	×	×	×	×		×	×	×	×	
Shackleton	United Kingdom	77° 57′ S.	37° 16′ W.	67° 22′ S.	16° 34′	×		×				×		×	×
McMurdo Sound	U.S.A.	77° 50′ S.	166° 36′ E.	79° 01′ S.	294° 18′	×		×							×
Scott Base Pram Point	New Zealand–U.S.A.	77° 51′ S.	166° 45′ E.	78° 59′ S.	294° 22′	×	×	×	×			×	×	×	×
Ellsworth	U.S.A.	77° 43′ S.	41° 07′ W.	66° 56′ S.	14° 42′	×		×	×		×	×			×
Komsomolskaya	U.S.S.R.	76° S.	80° E.	82° 49′ S.	94° 20′										
Halley Bay	United Kingdom	75° 31′ S.	26° 36′ W.	65° 47′ S.	24° 16′	×	×	×	×			×		×	×
Cape Hallett	U.S.A.–New Zealand	72° 25′ S.	170° 55′ E.	74·6° S.	279·0°	×	×	×	×					×	
Queen Maud Land	Norway	70° 30′ S.	01° W.	64·0° S.	44·9°	×	×	×							
Breid Bay	Belgium	70° S.	23° E.	67·4° S.	62·7°	×	×	×	×			×	×		
Pionerskaya	U.S.S.R.	69° 44′ S.	95° 30′ E.	80·3° S.	146·5°	×						×			
Charcot	France	69° 23′ S.	139° 02′ E.	78·3° S.	234·5°	×	×					×			
Showa Base	Japan	69° 02′ S.	39° 36′ E.	69·7° S.	77·4°	×	×	×	×		×	×	×	×	
Davis	Australia	68° 34′ S.	77° 56′ E.	76·6° S.	119·9°	×		×							×
General San Martin	Argentine	68° 08′ S.	67° 26′ W.	55·9° S.	0·5°	×		×				×	×	×	×
Horseshoe Island	United Kingdom	67° 49′ S.	67° 17′ W.	55·4° S.	1·2°	×		×							
Mawson	Australia, New Zealand	67° 36′ S.	62° 53′ E.	73·1° S.	103·6°	×		×	×		×				
Mawson	Australia	67° 35′ S.	62° 55′ E.	73·1° S.	103·0°		×		×			×	×	×	×
Dumont D'Urville	France	66° 40′ S.	140° 01′ E.	75·5° S.	230·9°	×	×	×	×				×	×	
Mirny	U.S.S.R.	66° 33′ S.	93° 00′ E.	77·0° S.	146·5°	×	×	×	×		×	×		×	
Wilkes	U.S.A.	66° 25′ S.	110° 27′ E.	77·9° S.	178·8°	×	×	×	×		×	×		×	×
Oasis	U.S.S.R.	66° 16′ S.	100° 44′ E.	77·4° S.	160·8°									×	
Graham Land	United Kingdom	66° S.	60° W.	54·6° S.	6·2°							×			
Gonzales Videla	Chile	65° 48′ S.	63° 05′ W.	54·4° S.	4·2°	×		×				×		×	×
Argentine Islands	United Kingdom	65° 15′ S.	64° 16′ W.	53·8° S.	3·3°	×	×	×					×	×	

tribution is used. A glance at this table shows immediately that certain investigations are linked with geographical regions; for example, glaciological investigations are particularly concentrated in the arctic and antarctic regions. In the other regions, observations are dependent on the presence of glaciers. From another point of view, observations of an astronomical character such as longitudes and latitudes, or even solar observations, are essentially based on the existing observatories. These tend to be concentrated in the northern hemisphere in the region of the middle latitudes.

However, it is impossible to regard all stations as being of equal importance, because within each discipline there are profound differences in the type of observations. In meteorology, for example, an aerological station will make at least radiosonde observations, while a radiation station need only have simple apparatus for measuring the total radiation, and the results obtained may not be very accurate. On the other hand, rockets, which numerically make the smallest contribution to the International Geophysical Year programme, represent an effort so much in excess of their numbers that only four National Committees, namely, Japan, the United Kingdom, the United States and the U.S.S.R., have been able to participate. The U.S.S.R. rocket and Earth satellite programme was presented to the Bureau of the Comité Spécial de l'Année Géophysique Internationale on June 16, 1957. A total of 125 rockets will be launched; of these, 25 will be fired in the Arctic, from Franz Joseph Land, 70 from the middle latitudes of the Soviet Union, and 30 from the region around Mirny in the Antarctic. The firings will be made at approximately regular intervals, mainly on World Days and Special World Days.

It may be interesting to point out how the observations being undertaken in one of the disciplines are subdivided. Observations of auroras can be visual, photographic, spectrophotometric, spectrographic or radioelectric, and the various techniques are essentially different. There will probably be more than two hundred stations observing auroras visually, to which can be added other observations made by meteorological stations and by amateur astronomers. In addition, there will be 104 all-sky cameras, which will make possible a continuous photographic record of auroras so far as clear skies allow, and of these fifty-nine will be in the Arctic region. The number of spectrographs will be about thirty-six, of which fifteen will be in the Arctic and nine in the Antarctic.

It is impossible to write in detail about the many subjects under investigation when giving an impression of the contribution of each National Committee organizing observations during the International Geophysical Year. However, geomagnetism may be taken as a typical example. Table 3 gives the schedule prepared for certain regions by various National Committees. There will be, according to this programme—which is, of course, an essential part of the Year's programme—178 geomagnetic stations registering the three components, D, H and Z. With regard to the numbers given in column a, these are not very significant, because the number of stations based on a portable instrument is practically unlimited.

Among the most remarkable efforts to be undertaken during the International Geophysical Year, the observations to be made in the polar regions are probably the most spectacular. The stations and observations that will be carried out in the Arctic are given in Table 4, and those in the Antarctic in Table 5.

This outline of the projected activities of the International Geophysical Year, though lacking in detailed description, nevertheless indicates a scientific reality of great magnitude. The whole object is to integrate a series of observations which require international co-operation on a scale never before realized. This has been achieved by a number of round-table talks, in which some of the world's leading astronomers, geophysicists, meteorologists and others have proposed, discussed and then agreed on suitable programmes. Finally—and this is the most important—it shows that a practical solution to the problems of modern science can only be found by mutual contributions to the task, as is illustrated so well by the efforts of the National Committees contributing to the International Geophysical Year.

GEOPHYSICAL INVESTIGATIONS ON THE FLOOR OF THE ATLANTIC OCEAN IN *DISCOVERY II*, 1956

A DISCUSSION meeting concerning the geophysical investigations made in the Atlantic from R.R.S. *Discovery II* in 1956 was held in the rooms of the Royal Society on May 2. Sir Cyril Hinshelwood, president of the Royal Society, was in the chair and the meeting was introduced by Sir Edward Bullard. He described the track (Fig. 1) of *Discovery II* on the cruise and the type of investigation which was made. While the ship was on passage continuous echo-sounding profiles and total force magnetic measurements were obtained. The station work consisted of seismic refraction shooting experiments, measurements of the heat flow through the ocean floor, coring, dredging, bottom photography and detailed magnetic and topographic surveys in a few limited areas. In addition to this, one measurement was made of the deep current at a depth of 3,000 m.

The scientific personnel on the expedition consisted of Mr. R. D. Adams, Sir Edward Bullard, Mr. J. C. Cleverly and Dr. M. N. Hill from the Department of Geodesy and Geophysics at Cambridge, Dr. R. G. Mason and Mr. F. Gray from the Imperial College of Science and Technology, Dr. A. S. Laughton and Dr. J. C. Swallow from the National Institute of Oceanography, and Prof. R. W. Raitt of the Scripps Institution of Oceanography in California, and Dr. T. F. Gaskell of British Petroleum Co., Ltd. The last two were each present for half the cruise.

An important new technique was used on the detailed surveys; this consisted of the mooring of dan buoys with radar reflectors on them in deep water. This allowed a better control of position to be obtained than is possible with astronomical sights alone. The new types of investigation used on the expedition were the photography of the sea-bed with

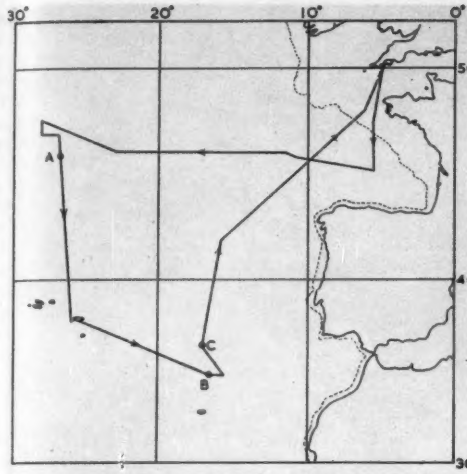

Fig. 1. Track of *Discovery II* during July and August 1956. Points *A*, *B* and *C* show where buoys were moored

Dr. A. S. Laughton's camera and the measurement of the Earth's total magnetic field with a towed nuclear-spin magnetometer.

Sir Edward completed his introductory remarks by acknowledging his gratitude to Dr. G. E. R. Deacon, director of the National Institute of Oceanography, for providing six weeks of *Discovery II's* time for these investigations.

Dr. M. N. Hill gave a brief description of the topography of the area of the Atlantic in which the recent investigations and those of earlier expeditions have been made. The area can be sub-divided into four different types of topographic terrains. First, to the north there is the extensive, comparatively shallow smooth area lying to the west of Scotland and extending to Iceland and Greenland. Secondly, there are the abyssal plains lying close to the foot of the continental shelf at depths of about 2,500–2,900 fathoms; these plains are isolated from one another by ridges and are generally flat to within a few parts in ten thousand and stretch out to a distance of approximately two to three hundred miles from the foot of the continental slope. The third type of topography lies to the west of the abyssal plains; it is shallower and consists of gently sloping areas with seamounts and ridges sticking up through the sedimentary cover. In width this third type is again about two to three hundred miles. Farther to the west, and centred about the line of 30° W. longitude, lies the Mid-Atlantic Ridge where the bottom topography is precipitous, with no extensive flat or smooth areas. The Ridge width is variable but is again in the neighbourhood of 300 miles. The minimum depth to the higher peaks of the Ridge is about 600 fathoms and the mean level in the middle about 1,300 fathoms.

In the middle of the Ridge and roughly following its axis there is a deep valley approximately 1,800–2,200 fathoms in depth. The floor of the valley is about five miles across, and between the tops of the ridges forming its sides the width is about 10 miles. This valley was discovered in cruises of H.M.S. *Challenger* by Dr. Swallow in 1953 and since then some detailed surveys have been made of restricted parts of it. Its length is at least 85 miles and it seems to be blocked at its southern end in about latitude 47° 20′ N. To the north its limit is not known. In the 1956 expedition the investigations were undertaken near its southern limit. Prof. M. Ewing has suggested that this valley exists with occasional breaks in it throughout the length of the Ridge from 55° N. lat. down to the latitude of Cape Town and that it there swings to the east and continues up the ridges in the western Indian Ocean. There is some support for this suggestion in the limited sounding information available, but its continuity is open to much doubt.

Dr. A. S. Laughton was the next speaker and he described the method of photography of the sea-bed which he has developed. The camera and flash tube are mounted on a framework of scaffold tubing and are arranged with the camera sufficiently far above the light source to allow for photographing of the shadows behind smaller objects lying on the sea-bed. The camera is operated by a weight hanging about 10 ft. below it. When this weight touches the sea-bed it triggers the flash and operates switches, one of which winds the film and another transmits a sound pulse back to the surface. This sound is a signal for the camera to be lifted clear of the bottom. Because of the drifting of the ship, subsequent lowerings will photograph different areas of the sea floor; up to one hundred photographs can be obtained before the camera need be brought back to the surface.

This camera was used at numerous positions during the cruise at depths between about 60 fathoms and 2,650 fathoms, and in all two hundred black-and-white photographs were obtained.

The most interesting series of photographs were those obtained from a seamount (Position *B* on Fig. 1) at the south-eastern corner of the track which was surveyed in detail. These demonstrated the existence of loose boulders on the sea-bed near the top of the seamount, outcrops of rock and pockets of sediments on the flanks (Fig. 2). In the deeper water there are oceanic sediments which, as was usually found elsewhere, are covered with numerous indications of the existence of bottom fauna. These photographs were all of great interest in relation to the rocks obtained by dredging in the area and to the topography obtained by the echo-sounder.

Mr. R. D. Adams, of the Department of Geodesy and Geophysics at Cambridge, who was to a large extent responsible for the seismic refraction shooting experiments undertaken during the cruise, described the seismological investigations he had made before and after the cruise. These were related to the refraction shooting results, since, by studying the Rayleigh and Love waves from earthquakes in the Mid-Atlantic Ridge, it was possible to learn some details of the average crustal structure below the Atlantic Ocean. The earthquake epicentres of the Ridge lie along the axis and exist throughout the length of the Ridge. Adams discussed the results from earthquakes from the northern part of the Ridge picked up at Kew and on the long-period seismographs at Cambridge.

It has previously been suggested by Prof. J. P. Rothé that on the eastern side of the Ridge the crustal structure is nearer that of the continents than on the western side and in other oceanic areas. This is not substantiated by the dispersion results obtained by Adams, which showed that, after the effects of the continental part of the track had been removed from the observations, the results were indistinguishable from those obtained from other oceanic areas.

Fig. 2. Loose boulders and some outcropping bedrock near the peak of a volcanic seamount north of Madeira. In the foreground is a spiralling Gorgonid. The depth of water was 800 fathoms

This conclusion agreed with the seismic refraction shooting results. Adams pointed out that interesting results concerning the Mid-Atlantic Ridge structure might be obtained from the installation of longer period seismographs in the Azores than those at present in use; the surface waves were not at present being recorded.

Dr. M. N. Hill gave a brief summary of the seismic refraction shooting results obtained from those areas, largely in the Atlantic and Pacific oceans, in which this type of measurement has been made and compared them with those obtained in the north-eastern Atlantic. The top layer (Layer 1) consists of unconsolidated sediments (compressional wave velocity 2 km./sec.) which in water depths greater than about 2,000 fathoms has an average thickness of approximately 350 m. This overlies a layer in which the velocity of compressional waves lies between 4 and 6 km./sec. and which has a mean thickness of about 1·6 km. This layer is difficult to identify; near volcanic islands it appears that it can be associated with lavas, but its existence in all areas makes it doubtful whether this interpretation can be true over all the sea floor. The velocity in it is such as might be expected for consolidated sedimentary rocks and it is possible that time and pressure have produced the necessary cementation or compaction of the deep sea sediments to produce this layer. The layer below this has a compressional wave velocity of 6·7 km./sec. and is usually supposed to represent basaltic rocks. Its thickness varies with location but in the deeper water it is approximately 4 km. thick and overlies the mantle rocks, which have a compressional wave velocity of 8·1 km./sec. This velocity is very close to that found at the Mohorovičić discontinuity at a depth of about 30 km. under the continents.

In the north-east Atlantic, seismic refraction shooting observations during the past years have been made at more than thirty different positions and with a few exceptions these results conform with those obtained elsewhere. The first exception exists in the relatively shallow northern area mentioned earlier, where the thickness of the unconsolidated sediments is considerably greater than elsewhere, being in the neighbourhood of 2 km. This thickening is possibly associated with the erosion products of the Pleistocene glaciation. The second exception is on the three seamounts and in the shallower water near the Azores, where there appears to be an additional layer, with compressional wave velocity about 3·8 km./sec., between the unconsolidated sediments and the layer usually lying below, which has a velocity in the eastern Atlantic between approximately 4·5 and 5·4 km./sec. This layer with velocity 3·8 km./sec. can with fair certainty be associated with volcanic lavas.

In the recent expedition a series of observations was made at increasing distances from the Azores, and these showed that apart from the changes in water depth, and a thickening of the unconsolidated sedimentary layer in the shallower water, the structure was similar to that found elsewhere. In these measurements the method did not allow the depth to the layer with velocity 8·1 km./sec. to be determined.

From the seismic observations obtained on the recent cruise of *Discovery II* and those obtained by Swallow and Hill on previous expeditions, it appears that the eastern Atlantic differs to no marked extent from the Pacific or the western Atlantic. Hill concluded his remarks by suggesting that those who favoured the hypothesis of continental drift in comparatively recent geological times would have difficulty in reconciling their conclusions with the crustal similarities between the Pacific and Atlantic Oceans.

Dr. M. N. Hill next described the nuclear spin magnetometer which had been constructed for towing astern of *Discovery II* during the expedition. This magnetometer relies upon the measurement of the precessional frequency of the spin axes of protons, the magnetic moment vectors of which have been displaced from alignment with the Earth's field and which are realigning themselves. The displacement of the protons in a water bottle is produced by a polarizing field not aligned with the Earth's field. This polarizing field is derived from a coil around the bottle; the coil is also used to detect the small

alternating magnetic field (which is about 2,000 c./s. in the latitude of Britain) produced by the precessing protons. The precessional frequency is directly proportional to the total field through the water sample. The advantages of the instrument are that calibration is unnecessary since the gyromagnetic ratio for the protons is known, and also that orientation of the bottle is not of importance provided its axis is not close to the direction of the Earth's field. This means that the object to be towed can be smaller than that of, for example, the towed fluxgate magnetometer. The body of the magnetometer used in the recent cruise was 5 ft. in length and 5 in. in outside diameter and was towed approximately 300 ft. astern. The electrical equipment necessary for the measurement of the precessional frequency was installed in the ship.

Sir Edward Bullard described the total force magnetic measurements which were obtained with the nuclear spin magnetometer and with the fluxgate magnetometer on the recent cruise. One of the first interesting observations which resulted from these magnetic measurements was that which suggested that the Hercynian folding forming the Brittany Peninsula extended out to sea. A crossing of the line of its axis extended out over the continental shelf was obtained early in the cruise and another on the return voyage to Plymouth, and both showed a considerable positive magnetic anomaly. Apart from this anomaly, the continental shelf and slope were magnetically smooth compared with the deeper water, where even in areas topographically flat considerable anomalies with a wave-length of the order of 12 miles were constantly observed. Even where there was some relief on the ocean floor it was not obvious if there was an association between these long wave-length anomalies and the topography. Superposed upon these long wave-length anomalies were those of about 2-miles wave-length which could sometimes be associated with topographic features.

Detailed magnetic surveys were made of the two seamounts where dan buoys were moored; although there appears to be some correlation between the depth and magnetic contours, it is not as good as would be expected if these seamounts, from a magnetic point of view, consisted of lumps of magnetic material placed upon the sea floor.

Dr. J. C. Swallow described the deep water current measurement which had been obtained on the cruise. The method consists of loading aluminium alloy tubes so that at the surface they are slightly negatively buoyant. Since their compressibility is less than that of water, it can be arranged by suitable weighting that they reach a known depth where they possess neutral buoyancy. The tubes contain electrical sound-making devices which allow the floats to be followed for some days. Their position is determined relative to a fixed topographic feature of the sea floor. With the observations made on this cruise the current at 1,640 fathoms was found to be approximately 0·8 cm./sec., or less than half a mile a day. The position of the observation was near the south-eastern corner of the track of *Discovery II* and the depth of water about 2,300 fathoms. Dr. Swallow considers the magnitude of this bottom current to be so small that it may represent 'noise'; in order to obtain a more reliable estimate of the permanent current, observations would have to continue for a longer period than two days (see also *Nature*, **179**, 1183; 1957).

Prof. W. F. Whittard spoke about a preliminary inspection he had made of the basalt boulders dredged from a seamount. These appeared at first sight to be weathered, since among other characteristics these rocks were exceptionally friable. It was difficult to understand how they could have got into this condition while resting on the floor of the deep ocean. Whittard also remarked that small pebbles dredged from the northern part of the Mid-Atlantic Ridge largely consisted of limestones and acidic igneous rocks. He expressed doubt if these could all have been ice rafted.

Mr. A. R. Smith reviewed previous work on cosmic spherules derived from atmospheric dust collections and ocean sediments. He mentioned two recent theoretical indirect lines of investigation which suggest that there is an abundant supply of these spherules in space and that they can get through our atmosphere undamaged. He outlined an experimental programme which he is carrying out at Cambridge on the deep-sea cores obtained from the recent cruise. It is hoped that it will be possible to devise a positive method of identification of these spherules and to find out something about their density and composition, and their distribution in space.

In the discussion Dr. G. E. R. Deacon expressed satisfaction that *Discovery II* proved so versatile that the measurements described could be satisfactorily undertaken. It spoke well for the design of the ship that after nearly thirty years service she was still suited to modern techniques.

M. N. HILL

THE UNIVERSITY OF READING

By SIR JOHN WOLFENDEN, C.B.E.
Vice-Chancellor

THE University of Reading is on the move, literally as well as metaphorically. The new building in Whiteknights Park which Her Majesty The Queen, accompanied by Prince Philip, recently opened is the first outward and visible sign of an imaginative and far-reaching plan of development. When this plan is completely realized the University of Reading will have a material equipment which will not easily be surpassed by any other University in Britain.

The original home of the University Extension College was in the heart of the town of Reading. It was a cluster of municipal buildings (some of which have to-day become part of the Police Station) provided by the Borough Council to meet the needs of adult education as it was understood in the 1890's. The site was cramped, the buildings quickly became inadequate, and the atmosphere was inappropriate to the academic ambitions which the principal, Dr. W. M. Childs, and his colleagues properly cherished.

The energetic enthusiasm of Childs and the generous faith of Alfred Palmer made an irresistible combination. Between them they brought it about

Fig. 1. Faculty of Letters: Main Building

that the College entered into possession of a substantial area of Palmer property, and to it the College moved in 1906. This London Road site had (and has) many attractions. Few of those who drive through Reading on their way from London to Bath realize either that a row of modest Georgian houses is the frontage of the University of Reading or that immediately behind those houses there are gardens and trees of a beauty and freshness quite unexpected thirty yards from a trunk road. Yet it is here that the University has lived, in simple dignity, for fifty years. The buildings, the open cloisters and the gardens themselves have made their impression on generations of students and have rightly earned their affection.

But year by year the pressure on space has inexorably increased. For Childs "There was room here to spread ourselves, and to house our work without overcrowding". But even by 1939, though, by comparison with other universities, Reading was still small, it was clear that the London Road site was no longer adequate. New departments and new needs had encroached on the lawns of the old gardens, and proper development was cramped for lack of space. The post-war demands for university expansion brought these difficulties to a head. It was simply impossible to meet them in surroundings which had been palatial for an infant college but were quite insufficient for a thriving and growing University.

In 1947 an opportunity arose, with dramatic unexpectedness. It was boldly seized, by the foresight of the then vice-chancellor, Sir Frank Stenton, and the University Council of the day. Whiteknights Park, an estate of three hundred acres on the southern fringe of the town, came into the market. The planning authorities, which had scheduled it as a permanent open space, generously agreed that it should be used for University development, and the first steps in a comprehensive scheme were taken. The University Grants Committee and the Treasury made their indispensable contribution, and the practical problems of planning were taken in hand. Architects were appointed, a site-plan was drawn up, and the University set itself the exciting task of working out its order of march from the London Road to Whiteknights Park.

It was inevitable that there should be delays and frustrations. Priorities change even in a period of ten years, specially when those ten years are as eventful as the last decade has been, both in public affairs at large and in the affairs of the universities of Great Britain. But on two important points there has been no departure from firmly held policies. First, the University is resolved that the beauty of Whiteknights Park should not be damaged, but should be positively enhanced, by the building of a university on it. The estate is a typical piece of English parkland, with pleasant contours, admirable trees, an interesting lake, and an attractive air of naturalness. The University is very conscious of its beauty, and of the obligation to pay full regard to it. The precise siting of buildings has been done in such a way as to preserve individual trees and to make the most of the existing background. There is no intention to sweep away what is already there and to start from a *tabula rasa*. Hundreds of new trees

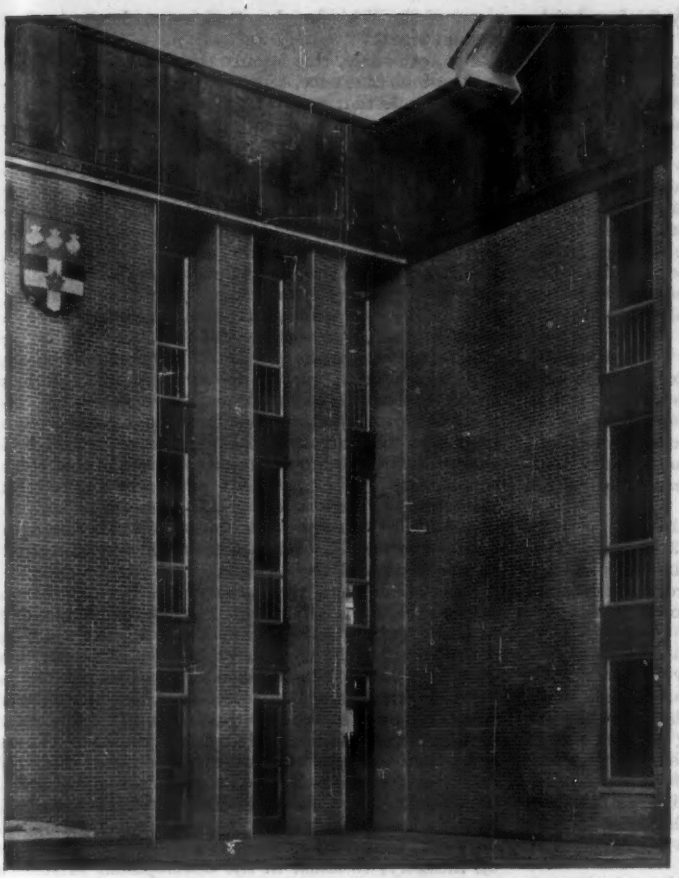

Fig. 2. Faculty of Letters: Main Entrance

have been planted—many of them a gift from the chancellor, Lord Templewood.

The University's second determination is that its organic life shall not be split in two by the gradual transfer from one site to another. Clearly, a move of this kind will take many years to complete, and during that time part of the University will be in Whiteknights Park while a diminishing part stays in the London Road. This problem is not unfamiliar in the history of university development, and there are lessons which Reading is gratefully learning from its sisters. But both its senior members and its student body are alive to the dangers of schizophrenia (or schizosomatosis) and resolved that topographical separation shall not mean disruption or divorce. The actual distances involved are not immense, by the standards of towns bigger than Reading; three-quarters of a suburban mile is not a sabbath day's journey.

In the autumn of 1954 Sir Frank Stenton cut the first turf on the site, and as he did so the first machines rolled on to the first building area. In May of 1955, Lord Templewood laid the foundation stone on a typical summer day of hail, thunder and torrential rain. On March 22, 1957, Her Majesty formally opened the first new building, in brilliant sunshine.

This building houses the Faculty of Letters. It concentrates the Departments of Philosophy, Classics, English, Italian, German, Political Economy, French, Modern History and Mathematics. Geography and Psychology, Departments which have one leg in the Faculty of Letters and one in the Faculty of Science, remain for the present with their scientific colleagues on the old site. There are common rooms, for academic staff and for students, lecture rooms, two departmental museums, and a private room for each member of the academic staff. The building contains a small theatre, inaugurated in March with a presentation of "King Lear".

It is a three-story building with a total area of approximately 65,000 sq. ft. It is a steel-framed structure with hollow block concrete floors and a low-pitched copper-covered roof. The external walls are built in Buckinghamshire Brown-Grey facing bricks, and the window panels are faced in Verde Oliva and San Stefano marble. The window frames are aluminium, set in African mahogany sub-frames.

Fig. 3. Faculty of Letters: Theatre

Internally, the wall finish is mainly fairface brickwork, Uxbridge Flint facing bricks being used for this purpose. Wood block flooring is extensively employed, although to reduce noise the corridors are finished in 'Korkoid'. The main entrance hall and staircase are paved in 'Travertine', and the columns in this area are faced in San Stefano and Ashburton marble.

The building is heated by means of Frenger Acoustic heated ceiling, a comparatively recent development consisting of perforated aluminium panels clipped to a continuous grid of heating pipes. The lighting throughout is by tungsten fittings, with the exception of the Classics Museum, which has fluorescent ceiling fittings and concealed tubes in the showcases.

The Departments of the Faculty of Letters are housed in the two long wings, each served by a subsidiary staircase. Nine lecture rooms are grouped in the centre block. Of these, seven are arranged to seat fifty students each, one to seat seventy-five, and one to seat a hundred. This last has a raked floor, and a projection room, which also serves the lecture room accommodating seventy-five.

In addition, on the first floor there is a fully equipped theatre with seating for 173 persons. This is approached directly from the main entrance hall and staircase. Underneath this theatre, on the ground floor, the main lavatory and cloakroom accommodation is grouped.

All the lecture rooms, and certain of the department rooms, are equipped with revolving or fixed blackboards, and in many of them a pull-down projection screen is also fitted. Special provision has been made throughout the building for the use of portable blackboards and display boards.

The two main common rooms, one for the academic staff and one for students, are located on the ground- and second-floors respectively, each with kitchen facilities. The academic staff room opens on to a paved terrace.

The architects are Messrs. Easton and Robertson and the quantity surveyors, Messrs. Hamilton H. Turner and Son. Consultants for the heating services, drainage work and landscape work are, respectively, Messrs. Donald Smith, Seymour and Rooley, Mr. Daniel Longden and Miss Mary Braendle. The builders are Taylor Woodrow Construction, Ltd.

By a triumphant combination of imagination and practical skill this quite large building sits comfortably and almost unobtrusively in its parkland setting. From every window in it there are trees and sky to be seen, and inside it there is an agreeable air of spaciousness and quiet. It succeeds in being friendly and domestic without losing dignity. The development of the Whiteknights Park estate has got off to a good start.

But, of course, this is only the first move. It has set the tone and pace, but it is really only a foretaste of the whole that is to be. The next moves promise to be no less exciting and no less arduous. Plans are well advanced for the two next buildings. They are to be a Hall of Residence and the Department of Physics.

It is natural that, in Reading especially, a new Hall of Residence should stand high on the priority list. On grounds of policy and of practical need, Reading has from the first developed the residential system as one of its distinguishing characteristics, and additional residential accommodation was a serious need even before the latest demands for expansion were made.

A new building for the Department of Physics is an equally urgent need. For many years the Department has conducted its multifarious activities on two separate sites, and the consequent waste of time and energy has for long been almost intolerable. To concentrate the Department in a new building in Whiteknights Park will ease this strain considerably, and will also be an important step towards removing one of the serious obstacles to an increased output of scientists and technologists.

Some time soon, the Library will have to move. Distances may not be great, but there is something rather startling in having a Faculty of Letters in one place and the University Library three-quarters of a mile away. The sudden bright thought of the lecturer, the immediate necessity for checking a reference, and, especially, the fostering of the habit of meditative reading, all demand that the gap in space between the student and the main body of his tools must be bridged as soon as can possibly be.

Other Departments of the Faculty of Science stand high in the queue. The Department of Geology is one, encouraged by handsome benefactions from the oil industry, to assist in the development of studies in sedimentology. Zoology and Microbiology, too, need much more space than is available on the London Road site if they are to make their proper contribution to national needs and to provide the required teaching for the Faculty of Agriculture.

So there will be no peace for the planners for many years yet. The heartening elements in the situation are the liveliness and enterprise of the Departments concerned, the understanding and concern of the University Grants Committee and the sensitive imagination of the architects. How long it will be before the whole of the University is safely housed in Whiteknights Park nobody can possibly know. But the move has begun, and hopes are high.

OBITUARIES

Prof. K. F. Bonhoeffer

The death of Karl Friedrich Bonhoeffer on May 15 at the age of fifty-eight deprived Germany of her foremost physical chemist. He was a member of a distinguished family: his father was professor of psychiatry at Berlin; his brother, who died some years ago, shared with Niemöller the lasting fame which came to those who championed the cause of the Church under Nazi tyranny. He served in the infantry in the First World War and was wounded in 1918. He suffered much also during the Second World War in another way.

Bonhoeffer's academic career began at the Universities of Tübingen and Berlin, where he graduated under Nernst and later became for seven years Haber's assistant at the Kaiser Wilhelm Institute in Dahlem. He successively occupied the chairs of physical chemistry at the Universities of Frankfurt-am-Main (1930), Leipzig (1934) and Berlin (1947), where he was also a director of the Kaiser Wilhelm

Institute for Physical Chemistry. From 1949 onwards he was director of the Max-Planck Physicochemical Institute at Göttingen.

His first researches were in photochemistry, and the "Grundlagen der Photochemie" (1933), which he wrote with Harteck, is one of the best monographs on that subject. The most widely known example of his application of spectroscopy to physicochemical problems is his investigation of the thermal dissociation of water vapour into hydrogen molecules and hydroxyl radicals, the presence of which was detected and the concentration of which was determined spectrometrically. His estimate of 103·3 kcal. per mole as the energy of atomization of hydroxyl remains unchallenged after thirty years. Free radicals have long been recognized as intermediaries in gas reactions. It is one thing, however, to postulate their existence in order to derive a kinetic law or to explain the course of reaction, and quite another to demonstrate the existence and to measure the concentration of a specific free radical. Within recent years many experimentalists have decided to follow Bonhoeffer's example.

Bonhoeffer's most spectacular scientific achievement came in 1929, when he isolated *para*-hydrogen. This proved to be a crucial experiment, to be followed by rapid developments of the quantum theory of chemistry.

Eucken had in 1912 obtained highly anomalous rotational heat capacities for ordinary hydrogen gas, and Mecke in 1924 had recorded a curious alternation of intensities in the spectra of molecular hydrogen. The interpretation of these two apparently disconnected phenomena was given independently in 1927 by Dennison, Heisenberg and Hund, according to whom ordinary hydrogen, hitherto regarded as a pure substance, was in fact a 3 : 1 mixture of *ortho*-hydrogen and *para*-hydrogen, which differed from each other in their nuclear spins and in the rotational energy-levels accessible to them. Physical chemists, while not unimpressed by mathematical arguments based on symmetry properties of wave functions, remained, on the whole, sceptical, and would scarcely have accepted the quantal interpretation were hydrogen gas to remain an inseparable mixture. In 1929, Bonhoeffer and Harteck showed that at low temperatures in the presence of charcoal the conversion of *ortho*-hydrogen to *para*-hydrogen was almost complete. They obtained a sample which was 99·7 per cent pure *para*-hydrogen. Its vapour pressure at the triple point was found to be 2·1 mm. higher than that of ordinary hydrogen and its boiling point 0·13° lower. His pupils, A. and L. Farkas, showed that the ordinarily forbidden interconversion of *ortho*- and *para*-hydrogen could be effected catalytically by paramagnetic molecules or radicals or by atomic exchange, and the reaction $H + p.H_2 = o.H_2 + H$ has proved to be the simplest of known chemical changes, now understood to the last detail.

Bonhoeffer and his school at Frankfurt-am-Main were among the first in the field with experiments on pure deuterium. He was generous with the 9·5-gm. sample of pure heavy water which his department had produced by the spring of 1934. Having schooled his own team to be satisfied with 100 mgm. each, to be recovered after their micro-work, he lavishly sent 1-gm. samples all over the world. It was from him that Rutherford obtained his first sample.

By 1935 it was clear that Bonhoeffer's interests were moving slowly away from physical chemistry to biology; papers appeared on deuterium in growing organisms, on the enzymic hydrolysis of glycosides in heavy water, and on the synthesis of polysaccharides in yeast cells. From 1941 onwards Bonhoeffer's principal experimental work dealt with membrane potentials and with the activation of passive iron as a physicochemical model of nerve excitation.

About half his publications appeared in the *Zeitschrift für physikalische Chemie*, of which he was editor with Bodenstein, Drucker and Simon from 1933 until his resignation in 1941. He was a founder editor of the new series of that journal which was issued in 1954.

Despite his tribulations, K. F. Bonhoeffer preserved an essentially sunny disposition, sustained by a supremely happy home life with his wife, daughter and three sons. He could relax, forget chemistry, enjoy music, and dance well. In his work, he had the enthusiasm of a boy and a gift for inspiring young men. Above all, he was blessed with the humility which is the hall-mark of greatness.

E. A. Moelwyn-Hughes

Dr. Otto Böhm

By the death of Dr. Otto Böhm on May 17, at the age of seventy-two, the Royal Naval Scientific Service has lost a distinguished and devoted servant.

He was born at Zaborze in Upper Silesia on July 2, 1884, and graduated in power engineering at Berlin, proceeding later to his doctorate at Darmstadt with a thesis on the effects of transients in high-voltage power lines. Joining the Telefunken Co., where his interests moved towards electromagnetic theory and radio, he rose rapidly to become director of research in 1922. In these years he made a number of original contributions to research on radio aerials, among them being the 'Tannenbaum' element so frequently used as a component of broadside arrays for high-frequency communications. It was with the Telefunken Co., also, that he did pioneer work on the reflexion of radio waves from obstacles.

But he was a Jew, unobtrusively proud of the accomplishments of his ancient race and inimical to the rising tide of Nazi doctrine. When eventually he stood in peril, the Telefunken Co. gave him due warning and provided an escort to Switzerland.

In 1936 Böhm came to England, and in 1941 to H.M. Signal School (now Admiralty Signal and Radar Establishment). The first experimental 10-cm. radars were then being made in the laboratories for naval use, and there followed an intensely productive period in which he originated one micro-wave aerial after another. At this time his invention of the 'cheese' aerial, to give a fan-shaped beam, was outstandingly apposite to the ship-borne radar problem. This was all pioneer work in a new field of applied science with no well-documented literature to show the way, and within a few weeks of their conception some of these aerials played vital parts in dramatic incidents both at sea and in coastal defence. To this work he brought a rare and remarkable combination of engineering design knowledge allied with an ability to go really deeply into the mathematical theory of aerial design.

His full-time service with the Establishment ended in 1946, but he continued as a consultant until his death, working as hard as ever and visiting the Establishment several times a month. His originality sparkled until the end, and in his last year he put forward a new approach to the problem of supergain

arrays which is in the vanguard of thought on this subject.

Otto Böhm was a liberally educated man, versed in the German poets and philosophers, and as ready to talk on the more obscure works of Thomas Mann as he was to exercise his specialized science. Courteous and gentle by nature, and warm in friendship, he would make real personal sacrifices to help any colleague in adversity. As a great teacher, he had an uncanny power for presenting difficult ideas in original and simple ways. It was a pleasure to watch him surrounded by four or five bright young scientists expounding some new idea, and to see him change his approach, or modify his argument, until he was quite sure all had understood. His face would then light up and the years seemed to fall away from him. Those enriched by these experiences, and all who sought him throughout the years, will feel the impact of Hilaire Belloc's lovely lines :

"He does not die that can bequeath
Some influence to the land he knows"—

for Otto Böhm loved England, and has bequeathed his influence abundantly. J. Croney

NEWS and VIEWS

Extraction Metallurgy at the Imperial College : Prof. F. D. Richardson

The establishment of a second chair of metallurgy in the University of London emphasizes the growing, if tardy, recognition of the importance of this subject, and it is fitting that a chair of extraction metallurgy should be located in the Royal School of Mines, where this branch of the subject has always received considerable attention. Dr. F. D. Richardson, who has been appointed to this chair, graduated in chemistry at University College, London, in 1933. After completing his postgraduate studies for the Ph.D. degree, he spent two years at the University of Princeton as a Commonwealth Fund fellow. At the outbreak of war in 1939, he was commissioned in the R.N.V.R. and his work on star shells during this period of service won for him an award from the Royal Commission on Awards to Inventors. Dr. Richardson's special interest in metallurgy commenced in 1946 when he was appointed superintendent chemist to the British Iron and Steel Research Association. During the next four years, while building up the Chemistry Department of that Association, he carried out theoretical and experimental investigations into the applications of thermodynamics to iron and steel making, work that has greatly increased our understanding of silicate melts and of the objects of slag control. As the result of these studies, the Sir George Beilby Memorial Award was conferred upon him in 1956, in recognition of his work on the thermodynamic properties of high-temperature systems, with special reference to iron smelting and steelmaking.

On the establishment, through a generous grant from the Nuffield Foundation, of a Nuffield Research Fellowship in extraction metallurgy at the Royal School of Mines, Dr. Richardson was appointed as the first Nuffield Research fellow in 1950. In that capacity, and with valuable additional support from the metallurgical industry, he has been enabled to form the Nuffield Research Group which is engaged in the extension of thermodynamic studies into the field of non-ferrous pyrometallurgy. Now that Dr. Richardson has been appointed to this new chair, it is to be expected that the investigations under his direction will be extended into the hydrometallurgical field that is of such growing importance. The eventual expansion of the metallurgy department, under the expansion scheme at the Imperial College of Science and Technology, should enable the Royal School of Mines to increase the supply of extraction metallurgists familiar with the modern trends in their profession and so enhance its reputation as the premier school in this branch of study.

International Geophysical Year : Awards of the Polar Medal

The following have been awarded the Polar Medal for good services as members of the advance party of the Royal Society Antarctic Expedition for the International Geophysical Year : *Clasp to the Polar Medal*, Surgeon Lieut.-Comdr. D. G. Dagliesh, R.N. (Sidcup), leader and medical officer ; K. E. C. Powell (West Ewell), senior diesel mechanic ; *Polar Medal*, A. R. F. Dagliesh (Sidcup), general duties ; Dr. S. Evans (Stockport), scientist ; Sgt. C. F. Le Feuvre, Royal Corps of Signals (Titton, Staffs), wireless operator ; D. W. S. Limbert (Finchley), meteorologist ; Lieut. G. R. Lush, R.N. (Cosham, Portsmouth), general mechanical engineer ; D. R. O. Prior (Norwood), carpenter ; J. E. Raymond (West Norwood), senior carpenter ; Major G. E. Watson, R.E.M.E. (Bromley, Kent), chief scientist.

The party were south of latitude 60° S. from about December 28, 1955, to February 1, 1957. The efforts of the expedition resulted in a notable acquisition of new knowledge of the meteorological conditions in that region, and, among other subjects, of the aurora australis and the habits of the Emperor Penguin.

University of Reading

Two publications, recently issued, show some aspects of the way the University of Reading is likely to develop. The first describes activities in the Museum of Rural Life during 1956 (Pp. 16. Reading : The University, 1957. 1*s.*) and contains details, not only of the exhibits, but also of three interesting exhibitions which were arranged at the Museum during the year. One of these was concerned with gardening in the eighteenth century, another with Welsh woodware and textiles, and the last with specialized forms of netting, lining and trapping used on the River Severn. The second publication (A History of Whiteknights. By Dr. Ernest Smith. Pp. iii+32 (4 plates). Reading : The University, 1957. 5*s.* 6*d.*) is a fine historical account of the origins and development of Whiteknights Park until its purchase by the University in 1947. With increasing pressure on land in this small island, this imaginative act may well lead to the University of Reading becoming one of the foremost residential universities in Great Britain. Both publications have been designed and produced with exquisite care and taste.

Canadian Journal of Chemical Engineering

In recognition of the growth of the chemical engineering profession in Canada the Chemical Institute of Canada is publishing a new journal, *The Canadian Journal of Chemical Engineering*, the first issue of which appeared in June. In publishing this new journal, the Institute has taken over the *Canadian Journal of Technology*, which was published by the National Research Council. The conversion and renaming of this long-established journal is designed to provide additional service to the chemical engineering members of the Institute, and to provide a medium of publication for the increasing amount of chemical engineering research and development that is being carried out in Canada. *The Canadian Journal of Chemical Engineering*, which will be published every second month, is edited by W. M. Campbell, of the Chemistry and Metallurgy Division, Atomic Energy of Canada, Ltd., Chalk River. Subscription rates are 3 dollars a year; U.K. and U.S.A., 4 dollars; foreign, 4.50 dollars; single copies, 75 c.

Transatlantic Travel

Political and Economic Planning published "Transatlantic Travel" (Broadsheet No. 410. Pp. 85–108. 2*s*. 6*d*.) on May 20, before the Chancellor of the Exchequer announced on June 4 that the ordinary travel allowance, at present £100 a year, would be available in future for travel to the dollar area, in the same manner as for travel in the transferable account area. The Chancellor attempted no estimate of the cost of this relaxation, but the Broadsheet estimates that for an additional dollar cost of £5 million, 40,000–50,000 more people could visit the United States and Canada each year. The Broadsheet, which includes a list of opportunities for study and travel in the United States and Canada, points out that whereas in 1956, 576,000 United States residents visited Europe, of whom 250,000 visited Britain, spending more than 80 million dollars—or 130 million dollars if travel is included—the total annual movement from Britain to the United States in recent years averaged about 37,000, of whom 10,000 were in transit to Australia or the Far East. Of the remainder, 8,500 were business men, about 1,200 had government or official visas, and 1,000 were on 'exchange' visas, mainly university professors or students. The total cost of travel abroad in 1956 was £123 million, of which travel to the dollar area represented £5 million, about one-third being in Canada and two-thirds in the United States. The Broadsheet is critical of other obstacles to travel, such as the visas required by the United States, and the rigorous regulations which must be satisfied before a visit to Canada is allowed. It also concludes that there is a strong case for extending the teacher-exchange scheme to other professions, and recommends establishment of a comprehensive agency with both the United States and Canada to foster such exchanges. Cheaper transport would facilitate a wider extension of university interchange, and much more could be done to encourage transatlantic travel for students.

A New Ferroelectric Material

Progress continues to be made with both methods and materials for the storage of digital information. Recently the Massachusetts Institute of Technology made use of superconductivity in a storage element called a 'cryotron' which occupies little more than 0·01 cm.^{3} per binary digit (bit). Now the Bell Telephone Laboratories, New York, have announced a new ferroelectric material, triglycine sulphate, particularly suited to switching and storage. Its coercive electric field is 220 V./cm., only one-fifth that of either barium titanate, the most widely studied ferroelectric material, or guanidinium aluminium sulphate hexahydrate (G.A.S.H.), a material described earlier by the Bell Telephone Laboratories. The Curie point of the new material is 47° C. (that of barium titanate being about 120° C., and of guanidinium aluminium sulphate hexahydrate not less than 200° C.), but can be raised to 60° C. or more by substituting deuterium for some of the hydrogen atoms. Switching times of a microsecond or two, such as have been realized also with barium titanate, are claimed (guanidinium aluminium sulphate hexahydrate responds much more slowly). Triglycine sulphate does not show the fatigue found in barium titanate after repeated switching, and will retain its polarization for long periods. When a wafer, 1 cm. square and 0·02 cm. thick, has a set of ten parallel strips of metal evaporated on to each of its two large faces, one set at right angles to the other, it can store 100 bits and be driven and read by circuits using transistors. The material is chemically stable, does not decompose on exposure to the air, and can be handled in thin sheets—three valuable secondary properties.

North Pacific Volcanoes

In the past two years studies by American and by Russian geologists have added greatly to our knowledge of the island arc volcanoes of the northern Pacific. In co-operation with the Department of Defense, the United States Geological Survey has lately completed an investigation of the eruptive centres of Alaska, the Aleutian islands, and the Pribilof archipelago ("Investigations of Alaskan Volcanoes", *Bull. U.S. Geol. Surv.*, No. 1028 *A-F*, 1955–56. Pp. 160+21 plates+36 figs.); while simultaneously the results of comparable work on volcanic and hydrothermal activity in Kamchatka and the Kurile Islands has been published in Moscow by the Academy of Sciences (*Trudy Laboratorii Vulkanologii*, No. 10, 82, 1955; No. 12, 218, 1956). In the Pribilof group, described by T. F. W. Barth (*Bull.*, 1028 *F*), the rocks differ from the andesites and basalts of the other volcanic centres in showing alkalic affinities, the basic lavas and tuffs being predominantly basanitic, sometimes with olivine bombs which are presumed to be derived from an exposed periodotite basement. The lengthy studies of Kamchatkan and Kurile volcanoes are replete with petrographical detail and in particular they give much new information on the composition of fumarolic gases. Surprisingly, neither the Russian nor the American authors refer to previous work by their national counterparts.

A Geological Garden

A geological garden constructed at Leeds by Dr. D. E. Owen is described in the issue of the *Museums Journal* for May 1957. A site within the grounds of Kirkstall Abbey was made available, and an outline map of England and Wales was marked by an 18-in. concrete path. Large, typical, clean, unweathered and uncut specimens of rocks measuring 3 ft. × 1 ft. 6 in. were then placed in their correct relative positions. Individual labels giving the name of the

rock and its locality, and a larger descriptive label set lectern fashion on an upright post, are provided, and a brief geological history of the country is available at the nearby branch museum.

Evaporation from Grass and Vegetables

PENMAN'S method of calculating from past temperature, rainfall and sunshine the amount of water necessary in irrigation to replace that lost by evaporation is based on experimental evidence for evaporation from grass. It has been hitherto assumed, in the application of the method, that the evaporation from other crops is the same as that from grass. N. E. Rider, of the Meteorological Office, working in the School of Agriculture, Cambridge, measuring the evaporation from bare soil, grass, peas and brussels sprouts during the early summer of 1955, found it was on some days much greater from the peas and sprouts than from grass. During the afternoon of June 18 the rate of evaporation from peas was equivalent to a water loss of 7·4 mm. a day, more than ten times the rate of 0·6 mm. a day from grass and the 0·4 mm. a day from soil. The rate from dry, bare soil was less than from grass. Both peas and sprouts formed a continuous cover over the ground. The rate of evaporation was not measured directly but by computation from Thornthwaite and Holzman's aerodynamic formula relating it to differences of wind speed and water content in the vertical direction immediately above the crop. The necessary delicate readings of wind and humidity were made with three types of apparatus, and most of Rider's paper (*Quart. J. Roy. Meteor. Soc.*, 83, 181; 1957) is devoted to justifying the accuracy of the observations. On one afternoon the rate of evaporation was about twice that for which energy could be provided by the intensity of sunshine measured at the nearest station, 60 miles away at Kew, but no error could be found in the instruments. Rider's work is of agricultural importance for deciding how much water to provide in irrigation.

Lethal Effects on Plant Cells of Fungal and Bacterial Extracts

A FURTHER contribution to this theme comes from S. G. Fushtey (*Annals of Botany*, N.S., 21, 273; 1957). When cucumber and turnip tissues were subjected to enzyme preparation of *Botrytis cinerea* and *Bacterium aroideae* in the presence of plasmolysing concentrations of various crystalloids, killing of cells was retarded out of all proportion to the slight retarding effect on maceration. When the tissue cells were recovered from plasmolysis they regained their sensitiveness to the toxic action. Toxicity of mercuric chloride and oxalic acid was also much reduced when cells were plasmolysed. Fractional precipitation with various proportions of acetone and over a wide range of *p*H gave preparations which varied in activity from one treatment to another, but their macerating and toxic actions varied together. After partial maceration, plant tissues were much more sensitive to the toxic action of mercuric chloride or oxalic acid. This is interpreted as meaning that, before maceration is complete, the toxic principle has been able to reach the protoplastic surface and to exert a deleterious effect upon it. The evidence presented gives further support to the view that the enzyme system of the two pathogenic organisms which macerates the host cell walls also brings about death of the protoplasts.

Brown Library, Liverpool

To mark the unveiling by H.M. Queen Elizabeth the Queen Mother on June 25 of a plaque commemorating the commencement of the rebuilding of the Brown Library as part of the celebrations of its centenary and of the 750th anniversary of the creation of Liverpool as a borough, the City Librarian, Dr. G. Chandler, has compiled an illustrated booklet (Centenary of the Brown Library and its Satellites, 1857–1957. Pp. 24. Liverpool: Central Public Libraries, 1957) recording the development of the several central libraries of Liverpool, all named after benefactors, and other principal donations to the Liverpool City Libraries. Besides the Brown Library itself, opened in 1860 and named after Sir William Brown, there are the Picton Reference Library, opened in 1879 and named after Sir James A. Picton, and the Hornby Library, presented by Mr. H. F. Hornby and opened in 1906. The Oak Library, opened in 1914, was built to house some of the most valuable books given to the city or acquired by special purchase, and the Commercial Library, opened in 1917, was considerably expanded in 1955. Rebuilding of the Brown Library will cost more than £400,000, and the area devoted to the temporary Technical Library (opened in 1952) will be used for the Record Office and local history collections when the Hunter Street block is built. The new modern building is expected to contain the permanent technical and patents libraries; the general reading room to replace the Christian Street library; a Central junior library with meeting and exhibition rooms; a lecture theatre to seat 850, which could also be used for public meetings; a large exhibition hall; staff and stock rooms; and accommodation for the Parents–Teachers–Youth collections temporarily housed in Blue Coat Chambers. The anniversary is also marked by an exhibition of books, manuscripts, water-colours and prints in the International Library, Central Public Libraries, during June 17 to September 28.

International Scientific Radio Union

THE twelfth General Assembly of the International Scientific Radio Union (U.R.S.I.) will be held at Boulder, Colorado, during August 22–September 5, by invitation of the U.S. National Committee of the Union and the U.S. National Academy of Sciences. Accounts of the previous meeting at The Hague in 1954 and of reports of its proceedings were given in *Nature* for September 3, 1955, p. 451, April 7, p. 652, and September 8, 1956, p. 528. Plans for the forthcoming meeting at Boulder have already been announced by the United States organizing committee under the chairmanship of Dr. J. H. Dellinger, honorary president of the International Scientific Radio Union. These include preliminary agenda for meetings of the seven commissions dealing, respectively, with radio measurements and standards, tropospheric and ionospheric propagation, noise of terrestrial origin, radio astronomy, and waves, circuits and electronics. The president of the International Scientific Radio Union for the General Assembly is Father P. Lejay (France). The Union is composed of national committees which contribute by subscription to its income and, as a result, are entitled to official representation and participation in its scientific work before and during each General Assembly. The British National Committee for Scientific Radio is organized under the auspices of

the Royal Society, with Mr. J. A. Ratcliffe as chairman. This committee has nominated a British delegation comprising scientists directly interested in one or more of the subjects of the commissions described above. This is the second meeting of the Union to be held in the United States, the 1927 General Assembly having been in Washington. The Boulder meeting will be of special interest in connexion with the programme of the International Geophysical Year, which starts on July 1.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: S. H. Abbott (superintendent of agriculture, Antigua, Leeward Islands), superintendent of agriculture, St. Kitts–Nevis–Anguilla, Leeward Islands; B. Butters (agricultural chemist, Uganda), soil fertility chemist, Uganda; K. S. Feltham (government chemist, Northern Region, Nigeria), federal government chemist, Federation of Nigeria; A. Rogerson (scientific officer, East African Veterinary Research Organization), senior scientific officer, East African Veterinary Research Organization; W. E. M. Logan (deputy chief conservator of forests, Tanganyika), deputy chief conservator of forests, Uganda; J. W. Barnes (geologist, Uganda), principal geologist, Uganda; E. F. Bradford (geologist, Federation of Malaya), principal geologist, Federation of Malaya; J. M. B. Harley (scientific officer, East African High Commission), senior scientific officer, East African High Commission; P. W. M. Allin (deputy director of surveys and lands, Northern Rhodesia), surveyor-general, Surveys Department, Northern Rhodesia; W. Gascoyne (senior surveyor, Western Region, Nigeria), deputy director of surveys, Western Region, Nigeria; W. M. Younger (chief surveyor, Department of Surveys and Lands, Northern Rhodesia), commissioner of lands, Lands Department, Northern Rhodesia; R. W. Butler (veterinary officer, Tanganyika), veterinary research officer, Tanganyika; A. Orhan (veterinary officer, class 1, Cyprus), chief veterinary officer, Cyprus; A. A. Brunt, plant pathologist, virologist, West African Cocoa Research Institute, Ghana; J. P. Parmiter, agricultural officer, Zanzibar; T. W. Tinsley, deputy director, West African Cacao Research Institute, Ibadan, Federation of Nigeria; R. D. H. Rowe, assistant conservator of forests, Kenya; A. T. Carr, geologist, Uganda; J. A. Cole, geologist (geophysicist), Federation of Nigeria; A. R. Drysdall, geologist, Northern Rhodesia; P. Ibbotson, geologist, Fiji; W. J. Jones-Davies, veterinary officer, Northern Nigeria; Dr. V. Balashor, physicist/chemist, Northern Rhodesia; A. E. Cockbain, palæontologist, Cyprus.

University News: London

UNIVERSITY chairs of applied mechanics, mining geology and technical optics have been instituted at the Imperial College of Science and Technology from October 1, 1957, to replace existing professorships in these subjects. The present holders of the professorships have been appointed to the newly instituted chairs as follows: Prof. H. Ford (applied mechanics); Prof. D. Williams (mining geology); Prof. W. D. Wright (technical optics).

Sheffield

THE following appointments in the University of Sheffield have been made: G. R. Hervey, as lecturer in physiology; Dr. B. B. Argent, as lecturer in metallurgy; D. Parsons, as assistant lecturer in physics; B. Truelove, as junior research fellow in botany; D. Bryce, as junior research fellow in zoology.

The University has accepted an offer by Messrs. Edgar Allen and Co., Ltd., to establish a postgraduate scholarship for study or research to be known as the Charles Kingston Everitt Memorial Scholarship, and an offer by Messrs. John Thompson, Ltd., of Wolverhampton, to establish a research scholarship in the Department of Mechanical Engineering to be known as the John Thompson Research Scholarship in Mechanical Engineering. The University has also accepted a generous donation of £4,000 from Messrs. Metropolitan-Vickers Electrical Co., Ltd. The donation will be used to provide equipment for the Department of Mechanical Engineering.

Announcements

MR. ELWYN JONES has been appointed to fill a vacancy in the membership of the Agricultural Research Council. Mr. Jones is a prominent Welsh farmer and a well-known breeder of Hereford cattle. He is keenly interested in all scientific developments in farming and has travelled extensively, particularly in North America, studying farming methods.

THE following officers of the Salters' Company have been elected for the year 1957–58: *Master*, Lieut.-Col. B. B. N. Woodd; *Upper Warden*, Sir Charles Goodeve; *Second Warden*, E. C. S. Price.

THE following have been elected officers of the Royal Meteorological Society for 1957–58: *President*, Prof. P. A. Sheppard; *Vice-Presidents*, Dr. A. W. Brewer, Dr. C. H. B. Priestley, Dr. R. C. Sutcliffe and R. G. Veryard; *Vice-President for Canada*, R. C. Graham; *Vice-President for Scotland*, J. R. Atkinson; *Treasurer*, Dr. J. S. Farquharson; *Secretaries*, P. J. Meade, Dr. H. L. Penman, Dr. G. D. Robinson (editor) and Dr. A. G. Forsdyke (librarian).

Immunology, the official journal of the newly formed British Society for Immunology, will be published by Blackwell Scientific Publications, Ltd. Contributions to the first issue, which will appear in January 1958, should be received by the editor, Prof. J. R. Marrack, Department of Pathology, Cambridge, by the end of July.

A COURSE in photoelasticity extending over the academic year 1957–58, and comprising weekly lectures on the theory and methods of photoelasticity, with particular emphasis upon the use of photoelastic methods in practical stress-analysis problems, is to be held in the Department of Civil and Municipal Engineering, University College, London, starting in September. Applications to attend and for further details should be made to the Secretary, University College, Gower Street, London, W.C.1.

IN the article in *Nature* of May 4, p. 900, par. 2, line 19, it is stated: "Records at Table Mountain also showed the increased atmospheric opacity arising from the Alaskan volcano in 1953 and from the explosions of nuclear or thermonuclear bombs". This is incorrect. The Report (p. 67) states: "Records from Table Mountain show clearly the increased opacity of the atmosphere arising from the Alaskan volcano in 1953. However, they show no effect of increased opacity arising from the explosions of nuclear or thermal nuclear bombs".

VAPOUR DETECTORS FOR GAS CHROMATOGRAPHY

An informal symposium on "Vapour Detectors for Gas Chromatography" was held in the Physical Chemistry Laboratory, Oxford, on May 3. The meeting was organized by the newly formed Gas Chromatography Discussion Group associated with the Institute of Petroleum, and was the first of a series of such meetings to be held twice yearly at centres throughout the country. More than two hundred participants attended and six papers were presented, the chairman and local organizer being Mr. C. S. G. Phillips.

In an introductory paper, Dr. A. I. M. Keulemans emphasized the importance of the detector in gas chromatography and the necessity for a continual improvement in its sensitivity. He directed attention to the recommendations made at the symposium in London during May 1956 [1], concerning the description of detector characteristics, and suggested that the method described by Dimbat, Porter and Stross [2] for comparing sensitivities was generally applicable. This expresses the sensitivity, S (in units of mV. ml./mgm.), in terms of the peak area obtained for a given weight of a component, but is only suitable for use with a chromatographic assembly of column and detector. A statement of the noise level, ε (in microvolts), is also required. The sensitivity of the detector alone is better defined as the minimum detectable vapour concentration (γ/ml. carrier gas), for a specific signal to noise ratio. Another speaker later commented that high sensitivity without a reasonably small detector volume and short time of response is not particularly useful for chromatographic purposes. Dr. Keulemans continued with a brief consideration of the relative merits of the thermal conductivity and β-ray ionization detectors. Although sensitive katharometers are comparatively easy and cheap to construct (S = 300–1,000, ε = 0–20) they suffer from two defects, namely, non-linearity of response, which necessitates calibration; and decomposition of vapours at high temperatures. These defects are largely overcome with the ionization detector, which can achieve a similar sensitivity and is much less sensitive to temperature changes. Expensive amplifying equipment is required, however.

The next two papers dealt with ionization detectors employing radioactive sources. Dr. H. Boer discussed the stability of the single-cell β-ray detector developed in the United States [3] compared with that of the balanced twin-cell arrangement he had already described (ref. 1, p. 169). To achieve a satisfactory zero drift, it is necessary to control the temperature of the former to within one-tenth per cent of the absolute temperature, but the latter is very much less sensitive. He had found it completely satisfactory to heat the twin-cell with infra-red lamps in a simple oven without a thermostat. Optimum cell depths, of the order of 15 mm., are only a fraction of the free path length of the β-particles in air, and tend to decrease with increasing source strength and become larger as the polarizing voltage is increased. The detector gives a good quantitative response with low vapour concentrations; corrections due to ionization cross-section are usually not very important. Dr. Boer finally described a modified twin cell detector requiring only a simple double triode amplifier, which was being tried at temperatures greater than 250° C.

In the second paper, Dr. J. E. Lovelock described another balanced twin-cell arrangement, but with the radioactive sources in the form of foil and with guard-rings on the ion collectors. He claimed, however, that the use of argon as carrier gas allowed a gain in sensitivity over the cross-section detector of at least one hundred to be achieved. This is possible because of the unique ionization properties of this gas. In common with the other rare gases, argon produces, on irradiation, many more excited atoms than ions, but the energy of these excited argon atoms is comparatively low (about 11·5 eV.). Additional ionization of vapour molecules by collision with these atoms occurs, but their energy is insufficient to affect any of the contaminants found in commercial argon. Although a 10-millicurie strontium-90 source was normally employed, the higher sensitivity made possible the use of an 80-microcurie radium source. With a polarizing voltage of about 700 V. the response had been shown to be linear at low vapour concentrations and a close function of the mole fraction for most common organic structures. The current produced by the detector is of the order of 5×10^{-9} amp., and this is recorded with the assistance of a simple electrometer amplifier. Dr. Lovelock commented that the detector had been successfully operated from 20° to 200° C., and that no zero drift took place when raising the column temperature through this range during the course of an analysis. Normal column loadings were in the range 0·1–1 mgm. when the minimum detectable amount at a signal to noise ratio of 2 : 1 was 5×10^{-7} moles.

The afternoon session opened with a paper by Mr. J. C. Hawkes on the use of the gas density balance at high temperatures. An earlier apparatus described by the author (ref. 1, p. 266) had operated successfully up to 300° C. using a vapour jacket. In considering a design to operate from 200° C. to as high as 550° C., difficulties with gaskets and the lack of thermally stable boiler liquids had necessitated the adoption of electrical heating for both the block and columns. The construction of the latest model was nearly complete and the uniformity of the temperature along the column had been kept within 2° C. even at an operating temperature of 500° C. Platinum resistance thermometers are employed as temperature controllers operating in an a.c. bridge circuit through phase-sensitive amplifiers to control the electrical input. In this way thermostatting to ± 0·3 per cent of the operating temperature is achieved. Many difficulties had been encountered in devising modes of construction to withstand the large temperature changes, particularly with the anemometer heater and thermocouple supports. The most satisfactory heater arrangement achieved had a hollow invar shaft surrounding a twin-hole porcelain tube through which stainless steel lead-wires passed. These were sealed to the ceramic with soda glass. To prevent corrosion the inside of the balance had been coated with nickel by a non-electrolytic method [4]. An interesting sample introduction system employing a

glass-phial crusher was described for use with the equipment.

The next speaker, Mr. J. R. Bishop, discussed the use of directly heated bead thermistors in thermal conductivity detectors. He presented data on the sensitivity of five different types of elements of both British and American manufacture. Using nitrogen as carrier gas, S values of 100–600 had been obtained with noise level lower than 10 microvolts. All types examined are stable up to 150–160° C. in nitrogen but with hydrogen as carrier gas the upper limit is only 100° C. at low bridge currents. With a bridge current of 15 milliamp. in hydrogen, noise appears, especially with uncoated beads, and at higher currents irreversible changes take place. A simple arrangement with a single thermistor supported in an extension 8 mm. in diameter at the end of a glass chromatographic column is effective and has a low detector volume. It is inherently sensitive to flow and this is best compensated by using another thermistor in the bridge, placed at the end of a second column. With the two elements connected in parallel to the applied voltage it was shown that the sensitivity was highest when the two fixed bridge resistors had values lower than the operating resistance of the thermistors. A detector with four thermistors connected in a bridge, which should give even higher sensitivity, was being constructed. Mr. Bishop directed attention to new American thermistors capable of operation up to 300° C., and illustrated the robustness of modern elements by describing how a colleague regularly cleans his detector with strong sulphuric acid. In conclusion, he commented on the possible use of thermistors for vapour detection based on specific heat rather than thermal conductivity differences.

One of the most recent detectors described, the low-pressure electric discharge, formed the subject of the last paper, by Dr. R. C. Pitkethly. Preliminary experiments with simple discharge tubes similar in construction to that used by Harley and Pretorius[5] demonstrated the very high sensitivity of the voltage drop across the discharge to small changes in concentration of hydrocarbon vapours in a stream of nitrogen passing through it. Early tubes, with platinum electrodes spaced a few centimetres apart, were very noisy and showed a poor linearity of response, with tailing of the peaks. These effects were attributed to electrode sputtering, changes in the number of bands in the positive column, poor scavenging and pronounced pressure sensitivity. An improved detector tube, employing a modified small neon indicator bulb, had been developed. This had comparatively large closely spaced iron electrodes, and was run at a pressure of about 3 mm. mercury with 200-300 V. across it. A pair of these tubes were connected to the ends of two columns with fine capillary tube, which provided the necessary pressure drop. They were operated in a simple bridge circuit with a double triode impedance changer to enable a standard high-speed potentiometric recorder to be employed. With this arrangement operated at room temperature, it is easily possible to detect a concentration of paraffin hydrocarbon gases in nitrogen of one part in ten million by volume. In the range C_3–C_5, the response to paraffins eluted in nitrogen from a column ranged from 9 to 38 volt–litres per micromole, rising with molecular weight. This sensitivity in the units proposed earlier is of the order of 3×10^8 mV. ml./mgm. with a noise level of 20 mV.

Before closing the meeting, the chairman invited Mr. R. P. W. Scott to describe his recent work with the hydrogen flame detector. A miniature bunsen burner-like attachment had been fixed to the top of the jet, which produced a pre-mixed flame more compact and stable than the original diffusion type. This, in conjunction with a platinum–rhodium/platinum thermocouple 0·004 in. in diameter on an improved support, had produced a marked increase in sensitivity. The minimum detectable concentration was now about 0·07 γ/ml. with a signal to noise ratio of four. D. H. DESTY

[1] "Vapour Phase Chromatography". Proceedings of a Symposium held in London, May 1956 (Butterworths, 1957).
[2] Dimbat, M., Porter, P. E., and Stross, F. H., *Anal. Chem.*, **28**, 290 (1956).
[3] Deal, C. H., Otvos, J. W., Smith, V. N., and Zucco, P. S., *Anal. Chem.*, **28**, 1958 (1956).
[4] Breuner, A., Couch, D. E., and Williams, F. K., *J. Res. Nat. Bur. Stand.*, **44**, 109 (1950).
[5] Harley, N., and Pretorius, V., *Nature*, **178**, 1244 (1956).

TRACE ELEMENTS IN SOILS, PLANTS AND ANIMALS

MORE than one hundred people listened with interest to papers and discussion at a symposium on trace elements in soils, plants and animals which was held in Bristol during April 10–12. Seven papers out of seventeen were contributed by workers at Long Ashton. C. Bould spoke on iron chelates for control of chlorosis in plants. With fruit trees, good results were obtained by applying chelates to the soil, provided that they were well watered in so that they reached the rooting zone before their iron was liberated by interaction with calcium. For strawberries or blackcurrants seasonal cure of chlorosis could be obtained by foliar sprays: a good wetting agent was essential. If chelates are absorbed in excess by plants there is a risk that minor elements may be affected. E. J. Hewitt reported that, with cauliflower, molybdenum is required not only for reduction of nitrate; when toxic accumulation of nitrate is avoided, by supplying nitrogen in other forms, deficiency of molybdenum has disturbing effects involving limited growth, reproductive failure and low concentration of ascorbic acid and, in cauliflower, symptoms of whiptail. In discussion it was mentioned that soil acidity, which is normally accompanied by lack of calcium, may cause plant injuries due to deficiency of molybdenum or excess of manganese and aluminium. D. J. D. Nicholas reported that in *Neurospora* and in green plants the step-wise reduction of nitrate to nitrite, to hyponitrite, to hydroxylamine, to ammonia was effected by flavin enzymes dependent on molybdenum, on copper and iron, on copper and iron, and on manganese, respectively. An alternative to the final step is the non-enzymic reaction of hydroxylamine with ketonic acids, resulting in the formation of oximes which are then reduced enzymically to amino-acids. That molybdenum is a constituent of nitrate reductase has been shown, because activity of the enzyme was diminished after dialysis in the presence of cyanide but was largely restored by adding molybdenum to the apoenzyme, whereas addition of various other elements was without effect. Strains of *Azotobacter* and *Clostridium* require molybdenum and iron for nitrogen fixation; in some instances vanadium or tungsten can replace molybdenum in this process. The hydrogenase enzyme, which is primarily iron-dependent, is not invariably coupled with nitrogen

fixation. Speaking of tropical agriculture, R. A. Webb noted that preoccupation with the major plant nutrients, nitrogen, phosphorus and potassium, had led to neglect of other nutrients which are now known to be essential for satisfactory growth of plants. He had obtained decisive indications of several elementary deficiencies with pot experiments in the Gambia by using subtractive techniques developed at Long Ashton. Similar results were now being obtained in other tropical areas. Successful fertilizer practice might require the use of mixtures supplying four or more essential nutrients. In discussion the need was stressed for sound agronomic practices and for numerous and widely scattered field experiments.

A. H. Williams described an investigation of certain organic compounds in plants and their variation with nutritional status; it was hoped that in plants suffering from nutrient deficiencies accumulation might occur of metabolic intermediates not readily detected in normal plants. Using paper chromatography, he found unusually large amounts of arginine in cauliflowers grown at low molybdenum-levels and supplied with nitrogen sources other than nitrate; when nitrate was supplied a low content of glutamic acid accompanied molybdenum deficiency. With tomato there is evidence that several linked metabolic processes are dislocated by deficiency of potassium or calcium or magnesium; this was associated with high levels of asparagine and glutamine and marked changes in the contents of malic and nitric acids and sugars. In discussion, the bearing of these studies on animal nutrition was mentioned. H. M. Stevens described the use of paper chromatography in the separation of valency states of biologically important metals: the method was applied to the preparation of pure cation solutions in known valency states which were used to determine valency changes in metals during enzymic action. C. F. Timberlake had found small quantities of copper, zinc, iron and lead in the tissues of fruit and still less in fruit juice. Copper occurs in polyphenol oxidase, but also occurs in ionic association with malic acid and in more stable complexes with amino-acids and with many phenolic compounds. At acid *p*H values normally found in fruits, only a small proportion of copper may be complexed with phenolic compounds: it acts as catalyst during their oxidation. In discussion it was noted that organic acids give copper complexes that differ widely in their stability and presumably in their nutritive value.

M. Fieldes and N. Wells reported that in New Zealand the composition of sweet vernal grass grown on 250 soil-types is being studied in a comprehensive scheme of analysis. Uptake of molybdenum by sweet vernal grass is related to molybdenum content of the topsoils and to the nature of the clay minerals, consisting in New Zealand mainly of hydrous oxides or allophane formed by weathering of primary minerals. Allophane contains aluminium in 4-co-ordination; molybdate and other anions containing oxygen are strongly held at broken bond sites in the clay and are less readily released to the plant. Molybdenum uptake thus decreases as weathering proceeds: it depends on *p*H also in a rather complicated way. In discussion, attention was directed to the large seasonal and other changes in composition of grass that make this kind of study difficult. This subject was treated by R. L. Mitchell, J. W. S. Reith and Isabel M. Johnston in a contribution from the Macaulay Institute. In Scottish soils the most important factor influencing trace-element availability is the drainage status. Under poor drainage conditions the extractable contents of many trace elements in soils are increased and in certain instances, notably cobalt and nickel, there is a corresponding increase in plant uptake. Numerous and detailed analyses of plants had shown such large changes in mineral content at different times of sampling that it now seemed that analysis of soil would prove a better guide to long-term plant content, provided suitable extractants could be found. For this purpose, ethylenediamine tetra-acetic acid (EDTA) may be more useful than acetic acid. A lively discussion ensued regarding the composition and analysis of pasture, which depends not only on soil but also on the proportion of grass to clover. It was mentioned that when pasture is deficient in cobalt the ruminant derives little or no benefit from soil ingested with the fodder.

Having in mind the Long Ashton work on factors involved under the general heading of soil acidity, E. G. Hallsworth, E. A. N. Greenwood and Jane Auden had grown clover, lucerne and lupin in sand and water cultures to study their reactions to low calcium- and high manganese- and aluminium-levels and had found serious restriction to growth in plants showing no toxicity symptoms. In experiments with subterranean clover, growth was restricted when copper was supplied at a low level, but the injury was not otherwise conspicuous; by increasing the copper supply a three-fold increase in dry matter production was obtained. With low levels of copper, phosphorus and molybdenum the plants were perfect miniatures. This effect was not confirmed in a later experiment: the discrepancy is ascribed to climatic conditions, in that symptoms of toxicity or deficiency are most evident when plants are growing vigorously.

A. Thompson's paper on the trace-element contents of herbage plants was presented by Mr. Brynmor Thomas. Supplementing earlier reports, analytical data were given for eight grasses, four legumes and four herbs from Cockle Park; hand-picked specimens of eight herbage plants from plots treated with fertilizers and manures for fifty years showed no large differences in their content of copper or cobalt. Samples from the Palace Leys hay plots showed differences in trace-element content that are ascribed mainly to differences in botanical composition. It cannot be assumed that minerals in fodder are wholly or uniformly available to the animal; for anæmic rats grasses are a better source of iron than legumes or herbs, but all three are inferior to ferric chloride. Aluminium exceeding 200 p.p.m. of the dry matter indicates contamination with soil. There was some discussion on differences in manganese between A. Thompson's analyses and those of R. L. Mitchell. It was noted by E. A. N. Greenwood that variation in manganese content of lucerne at Sutton Bonington had been traced to variation in illumination.

H. A. Robertson and A. W. J. Broome recorded that injection of thyroxine (four sheep) was followed by a rise in the level of blood sugar and rapid respiration with a slow return to normal, while dosing with thiouracil (two sheep) produced a notable fall in the level of blood sugar and apparently a less slow recovery. There was an inverse change in blood cholesterol. No change was observed in one sheep receiving gradually increasing injections of DNOC. It is inferred that blood-levels of copper depend on activity of the thyroid gland, which affects the basal metabolic activity. In discussion it was noted that

both thyroxine and thiouracil form complexes with copper.

C. F. Mills's paper on dietary factors influencing copper utilization by the animal was presented by Dr. D. P. Cuthbertson. The greater part of the copper in herbage is in the form of fairly stable organic complexes. Copper in herbage, and in aqueous extracts made from herbage, is more readily available to rats than an equivalent amount of cupric sulphate: the copper complexes present in the extract are not decomposed at ranges of acidity such as occur in the gastric contents of the rat; nor are they decomposed in the digestive tract of the sheep but seem to be absorbed intact. The lower availability of ionic copper may be ascribed to the formation of insoluble compounds. Discussion followed regarding conflicting findings with swayback in sheep. It was noted that in animals excess zinc reduces the activity of cytochrome-c oxidase, whereas copper restores it; in micro-organisms molybdenum has a similar effect to zinc, and the molybdenum–copper interrelationship therefore seemed worth studying in animal enzyme systems.

Copper nutrition in ruminants was further discussed in a paper by Ruth Allcroft and Gwyneth Lewis, who observed that copper deficiency in cattle and sheep in the United Kingdom occurs on pastures with an apparently normal or even high copper content. This is in contrast to parts of Australia and New Zealand, where the disorder is regarded as a simple copper deficiency associated with a low copper content of pastures—usually less than 5 p.p.m. Observations in the United Kingdom indicate the presence of other factors in the herbage which interfere with the utilization and storage of copper in the animal. Australian work has shown that a high molybdenum intake can limit liver copper storage in sheep and cattle, and that the inorganic sulphate content of the diet influences the effect of molybdenum. Evidence obtained so far indicates that the copper, molybdenum and inorganic sulphate contents of the food are not the only factors concerned in the occurrence of copper deficiency in ruminants in Britain. Some of the complexities of copper metabolism were discussed and the possible danger of over-supplementation with copperized mineral mixtures was pointed out. E. J. Butler commented on the gross disparity of pathological symptoms associated with copper deficiency; he agreed that low copper content in pasture does not always lead to swayback. H. A. Robertson mentioned a flock of sheep which was healthy in spite of low levels of blood copper. J. W. S. Reith said there were areas in north-eastern Scotland where crops had responded to application of copper, but animals showed no deficiency in spite of the low level of copper in the pasture.

Classical examples of cobalt deficiency occurring in Connemara were reported by L. B. O'Moore. The disorder occurs with cattle grazing on a calcareous sand of the coastal area and with sheep, especially with recently weaned lambs, pastured on certain acid peats in the inland hill area. On the same peats, cattle are liable to suffer aphosphorosis. The traditional way of avoiding these troubles is to move stock to different grazing areas. However, fortnightly drenching with cobalt sulphate is effective in the coastal sand-blown pastures; top dressing with cobalt is advocated for acid peat land.

A. D. Osborne has found a moderate degree of cobalt deficiency in some parts of north Herefordshire. No severe symptoms appear, but male lambs gain weight more rapidly when given a fortnightly drench of cobalt sulphate; female lambs benefit less from the treatment. In discussion, J. B. E. Patterson noted that the subclinical deficiency is of financial importance to the farmer. The investigation has been difficult, since analytical data for soil and for pasture do not give a clear picture: limits found acceptable elsewhere are not satisfactory here.

Confirming observations in the United States, D. B. Bellis and J. McL. Philp, by adding zinc to the dry feed of 8–16-week-old pigs, obtained spectacular cures of parakeratosis, a severe disorder of the skin accompanied by reduced growth. In discussion, it was asserted that the syndrome is mainly due to excessive amounts of calcium carbonate incorporated in proprietary pig feeds; the diet quoted by the authors is high in calcium and low in phosphorus. Work is being continued with a range of calcium/phosphorus ratios.

On April 12, symposium members visited the Long Ashton Research Station and the University of Bristol Veterinary Laboratory at Langford and the artificial insemination unit of Horlicks Farms and Dairies, Ltd. The symposium was organized jointly by the Agriculture Group and the Bristol Section of the Society of Chemical Industry. The organizers owed a particular debt to Prof. T. Wallace and his colleagues for the success of the meeting. The papers and discussions of the symposium will appear in a supplementary issue of the *Journal of the Science of Food and Agriculture* later this summer.

SEMICONDUCTORS

THE subject of the Spring (1956) Meeting of the Physical Society, organized with the assistance of British Thomson-Houston, Ltd., was "Semiconductors". The report* of the meeting has now, a little belatedly, been published; it contains all but one of the twenty-three papers read, but not the discussions.

Prof. N. F. Mott opened the meeting with his ideas on the transition to metallic conduction via impurity states in a semiconductor. He sought to show that in an array of monovalent atoms, the overlapping of the wave functions of adjacent atoms, though making electron transfer possible, does not necessarily lead to freely mobile carriers. He contested the assumption that an array of singly charged centres in a semiconductor, containing only donors or only acceptors, can be treated as a half-filled band. Confirmation of his prediction, that transition to metallic conduction with increase of concentration of monovalent dissolved atoms will be sudden, may have to await a sample of a semiconductor with regularly spaced donors or acceptors.

Another speaker introduced the idea of a 'semiconductor bond'. It does not exclude one (A) of the two atoms of a compound AB having incomplete s- and p-orbitals, provided there is no bonding together of the A atoms. Some predictions of new semiconducting compounds were made, based on a simple relation between the number of valence electrons per molecule, the number of atoms of the molecule lying in Groups IV–VII and any bonding between these atoms.

* Report of the Meeting on Semiconductors held by the Physical Society, in collaboration with British Thomson-Houston, Ltd., Rugby, in April 1956. Pp. 153. (London: Physical Society, 1957.) 20*s*. (12*s*. 6*d*. to members).

Almost all the other papers dealt with practice—technology and measurements—or with the properties of junctions. In the main they consolidated or clarified earlier work, or directed more detailed attention to outstanding problems; some contained comprehensive measurements. Only a few of the many points made can be reviewed here.

Improved trace-analysis has been needed to assist the purification of silicon. The common donor elements can now be estimated to 1 part in 10^9 by methods using radioactivation; equally sensitive methods are still lacking, however, for two acceptor elements, boron and aluminium. The rates of evaporation of donor and acceptor elements from molten silicon have been measured; when proper attention is paid to them, as well as to segregation constants, control of resistivity of single crystals grown from the melt is much improved. Carrier life-time in silicon is markedly dependent on injection-level; values for very low levels, obtained in part by extrapolation, have enabled a study of dependence on temperature to be commenced.

It has been suggested that most of the carriers responsible for the reverse current of a p-n junction in silicon are generated, not in the n- or p-regions, but in the depletion layer. New measurements, showing the current to have an activation energy of only 0·7 eV., point to the current arising in a surface channel. An analysis of a model of a p-n rectifier, intermediate between the one-junction (p-n-ohmic) and two-junction (p-n-n^+) models, was presented; it, too, predicted a two-component forward current-voltage relationship, $I \propto \exp(qV/kT)$ at small voltages and $I \propto \exp(qV/2KT)$ at large voltages.

The non-ohmic conductivity of n-type germanium has been measured for fields less than, as well as greater than, 10^3 V./cm. For fields between 10^4 and 6×10^4 V./cm. it is so pronounced that the electron drift-velocity changes very little; thereafter avalanche multiplication sets in. Many of the properties of small-area diodes can be explained by these phenomena alone.

There were contributions on noise—an endeavour to detect shot-noise—surface conduction and the Ettingshausen effect, all in germanium.

Compound semiconductors also received attention. Extensive measurements were reported for indium antimonide and indium arsenide—for both of which some degeneracy remained at all temperatures even in the purest samples—and for gallium arsenide of improved purity, many donors having been removed by zone-refining. Measurements of photo-effects in indium antimonide were used to deduce carrier mobilities, μ_e and μ_h, and life-time. There was marked dependence of μ_e on hole-concentration in p material; life-times were short, less than 0·1 microsec., at room temperature. The spectrum of recombination radiation from indium antimonide has now been measured; because the absorption spectrum of thin specimens enables a value of radiation life-time of about 0·8 microsec. to be deduced, which is little more than some experimental values of carrier life-time, it was concluded that recombination in indium antimonide may be mainly radiative.

The electron contribution to the thermal conductivity, at room temperature, of an impure sample of indium antimonide (Hall constant 2×10^{-4} cm.^{3}/coulomb) was calculated to account for the observed increase above the value for a purer sample (5×10^{-3} cm.^{3}/coulomb). However, whereas the electronic contribution in extrinsic bismuth telluride conformed with existing theory, the contribution in intrinsic material was more than expected, probably due to the transfer of ionization energy down a thermal gradient.

The nuclear resonance of indium-115 in highly degenerate n-type indium antimonide was shown not to differ in frequency from that in intrinsic material (that is, the Knight shift was absent); an adequate explanation lies in the very small effective mass of conduction-electrons in indium antimonide. The size and shape of the resonance are sensitive to cold working of the crystals and to the addition of tellurium as a donor.

The many informal discussions, possible because the audience was in residence, continually stressed the need for more frequent, similar, meetings. The subject has entered so many fields of science and technology, and so quickly finds new applications of effects, that the workers in the field, many of them young, have difficulty in keeping themselves adequately informed.

J. R. Tillman

THE WHISTLED LANGUAGE OF LA GOMERA

La Gomera is one of the Canary Islands, lying in the Atlantic off the west coast of North Africa. It is inhabited by some 30,000 Spanish-speaking people, scattered over the island in many tiny hamlets and four little towns. The island, volcanic in origin, is distinguished by a rugged and peculiar topography. It has the general shape of a big tent; from a central peak some 4,500 ft. high it slopes down on all sides to sheer cliffs at the sea's edge. Deep gorges radiating from the centre cut up the terrain. It is a difficult, mountainous country where two points only 500 yards apart as the crow flies may be as much as an hour apart in walking time. Apart from a single road, which links San Sebastian, the capital, with the other three towns, the only means of travel between most points on the island is by rough paths which are little better than goat tracks; communication on the island is a great problem.

But the Gomeros do communicate freely, across their ravines and from the valleys to the mountain-tops. The method of communication has been described in an article by André Classe (*Sci. Amer.*, 196, No. 5; May 1957). Long ago the Gomeros contrived an elegant solution to their problem: namely, a whistled language by which they speak to each other across miles of disjoined terrain. The *silbo*, as this language is called, is not a mere code or signal system but a version of Spanish. It has extraordinary carrying power: it can be heard and understood clearly over far greater distances than shouted talk. On a windless day any practised *silbador* can be heard more than a mile away. A good performer can whistle messages three miles or more.

On La Gomera, goatherds on widely separated hills carry on *silbo* conversations merely to pass the time. They whistle long sentences and even make jokes. During the Spanish Civil War in 1936–39 Gomeros were used occasionally for communication at the front; but the practice was discontinued when it was discovered that there were *silbadores* on both sides, so that the degree of secrecy was not high.

This curious medium of communication owes its existence to the geography of La Gomera. It goes back to the aborigines who inhabited it before the Spanish arrived in the fifteenth century. The aboriginal residents in the Canary Islands, called the Guanches, had developed a whistled form of their language for communication in their territory, then so thickly wooded that whistles were the only kind of 'talk' which could be transmitted for any distance.

The *silbo* is based directly on the Spanish language and is learned effortlessly and as a matter of course by most Gomeros. Children on La Gomera pick up *silbo* as naturally as they pick up spoken Spanish in their parents' talk; they often begin to recognize their own name in *silbo* before they are a year old.

The fact that the whistled language depends only on pitch explains why it can be understood at much greater distances than ordinary shouted speech. The sounds of ordinary speech are complex waves containing a number of harmonics. What makes such speech unintelligible at a distance is the loss of the weak harmonics and transients. On the other hand, a whistled signal, the meaning of which does not depend on timbre but is determined solely by pitch, will be understood perfectly so long as it is heard at all.

How does the *silbo*, using only variations in the pitch of a whistle, express the sounds of Spanish? It is fortunate that the language is Spanish; it would be vastly more difficult to whistle English, for English has a complex phonetic system. The Spanish phonetic system, especially in the Gomero dialect, is almost the simplest possible: it has comparatively few different vowel and consonant sounds, and relatively little contribution to meaning is made by stress, rhythm or intonation. All the *silbador* has to do is put the tip of his tongue against his teeth, start whistling and, at the same time, try to articulate words as if he were speaking normally. A practised *silbador* can whistle intelligibly everything he can say in the Spanish language. The whistle does not differentiate all the consonants in the spoken language, but when the *silbador* whistles words and sentences, the context makes his meaning unambiguous. Like ordinary speech, the *silbo* is differentiated into dialects and even individual styles. Each *silbador* has his own delivery.

Nothing better illustrates how commonly the Gomeros use the *silbo* than an experience Classe had one day in the wilds of the middle of the island. He was climbing the central mountain and all around in the woods were blackbirds whistling, not their own bird songs but, unmistakably and with excellent articulation, the *silbo* for the names 'Felipe', 'Alfonso', 'Frederico' and so on. In each case the bird prefixed the name with the attention-calling sound 'ah', which invariably precedes a call in the *silbo*.

The *silbo* of La Gomera is by no means the only whistled language in the world; but it is the most explicit. Other whistled forms of communication, found in Mexico and some parts of Africa, are made up of the tones, isolated from the other elements of speech, and convey meaning by a kind of musical accent. Generally speaking these other whistled languages are far less accurate, less explicit and more limited in power of expression than the *silbo*. The *silbo* is of great interest to a linguist because it does without what is commonly thought to be the one indispensable feature of normal speech: namely, variation of tone quality.

PASSIVATION OF IRON BY CHROMATE SOLUTIONS

ESTIMATIONS, in this Laboratory[1] and elsewhere[2], of the amount of chromium in the protective films formed on iron during immersion in potassium chromate solution have been reported. Further measurements in this Laboratory, using the radioactive tracer technique previously reported[1], have yielded results apparently of considerable theoretical interest. Publication of these results (apart from summaries in "Chemistry Research"[3]) has been delayed because of some uncertainty concerning the effect of the method of preparation of the radioactive potassium chromate solution (labelled with chromium-51) on the absolute figures for uptake of chromium, though it has been apparent for some time that the figures obtained have given useful relative results. (It is desirable to record here that slow precipitation of trivalent chromium in some earlier solutions[1] led to an incorrect conclusion concerning the effect of concentration of chromate on uptake of chromium; the concentration now appears to have little effect on uptake.) In view of the wide interest in the mechanism of corrosion inhibition, passivity and film growth at room temperatures, it now seems opportune to publish an abbreviated account of some of these results.

A family of curves has been obtained (Fig. 1) by plotting uptake of chromium against $\log_{10}(t_s + 1)$ (where t_s is time of immersion in chromate), for various times of pre-exposure of the specimens to air (t_a) before immersion. The nature of this family of curves has been interpreted as follows. The curve for the relatively short time $t_a = 5$ min. shows that uptake of chromium is a linear function of the logarithm of time. If it is reasonably assumed that the chromium, which has been detected only as Cr^{3+} (presumably in the form of Cr_2O_3), constitutes a constant proportion of the growing film, this relationship with time also applies to the film growth. The remainder of the curves (t_a greater than 5 min.) show the same 'logarithmic' film growth in chromate solution, but are displaced downwards because growth of the oxide film had already started in air before immersion of the specimen in the chromate solution; a straight line plot of growth v. log (time) can only be obtained if both growth increments and time are measured from the moment of start of growth. It can readily be shown that uptake curves for chromium (t_a not negligible) should, starting from a common origin, become parallel to the original straight line (t_a negligible), when t_s is very much larger than t_a, and that, further, this parallel portion will be displaced downwards by an amount proportional to the growth already present at the new starting point. It has, in fact, been found that this downward displacement is proportional to $\log_{10}(t_a + 1)$ for the various curves,

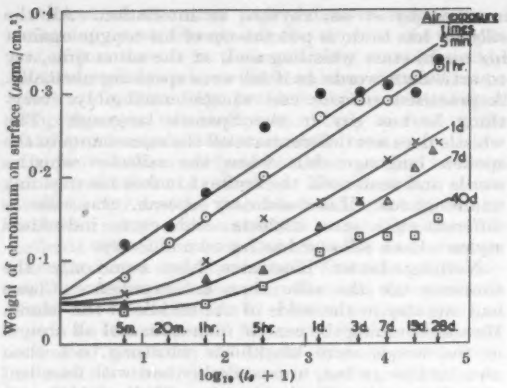

Fig. 1. Uptake of chromium by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5, after exposure to air for different periods, v. $\log_{10}(t_0 + 1)$. (t_0 = time of immersion in minutes)

thus demonstrating, in addition, that oxide growth in air before immersion is also a linear function of the logarithm of time.

Since film growth in air and in chromate solution are both linear functions of log (time), differing only in their rate constants, it is concluded that the growth mechanism in the two conditions is identical. Dr. O. Kubaschewski, of the Metallurgy Division, National Physical Laboratory (private discussion), has related this mechanism to Hauffe and Ilschner's[4] extension of a theory of Mott[5]. According to this extended theory, the rate of growth of very thin films is controlled by electron transfer through the film. Provisional estimates of the thickness of the films after some two to three weeks growth in air or chromate based on a ratio of iron to chromium in the 'chromate-grown' film of 3 : 1 are of the order of 40–60 A. Preliminary calculations (Brasher, D. M., and Nurse, T. J., unpublished results) have shown the relative oxidation-rates to be of the expected order; final calculations must await further experimental results both on uptake of chromium and on iron chromium ratios in the stripped films.

We thank Dr. F. Wormwell and other colleagues in the Corrosion and Radiochemical Groups for useful discussions and the Radiochemical Group for estimating the radioactivity on the specimens. The work was carried out as part of the corrosion research programme of the Chemistry Research Board, and this communication is published by permission of the Director of the Chemical Research Laboratory, Department of Scientific and Industrial Research, and of the Senior Representative in the United Kingdom of the Australian Department of Supply.

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Work subsequent to that described above has demonstrated that the rate of uptake of chromium, and hence presumably the rate of oxidation by chromate ion, is considerably influenced by the amount of oxygen in the solution (Fig. 1). The rate in a solution saturated with nitrogen is more than double that occurring in the same solution saturated with oxygen. It would appear that oxygen and chromate ions compete in oxidizing the iron surface.

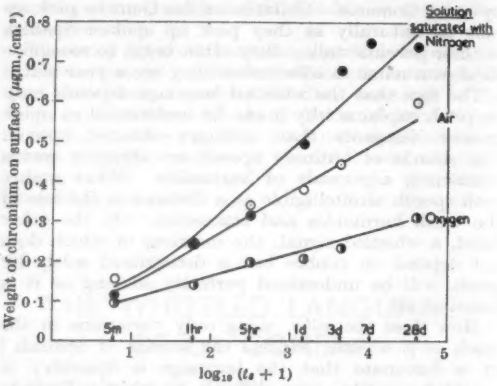

Fig. 1. Effect of dissolved oxygen on uptake of chromium by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5. Specimens pre-exposed to air for 1 hr. (t_0 = time of immersion in minutes)

Reference to Fig. 1 in the previous communication shows that the curves all cut the chromium uptake axis at approximately the same point, representing about 0·05–0·1 μgm. chromium/sq. cm. This was then considered to represent an adsorbed layer, the true chromium uptake curve probably rising rapidly from zero before forming part of the series of logarithmic growth curves. This assumption seems reasonable, since the total amount taken up corresponds approximately to a monolayer, and is (virtually) independent of the age of the oxide film at the moment of immersion. Points on the curve near the origin have now been obtained (Fig. 2) and clearly show the rapid formation of this layer before the true 'logarithmic' film growth begins.

The picture of inhibition by chromate can now be imagined somewhat as follows. Immediately on

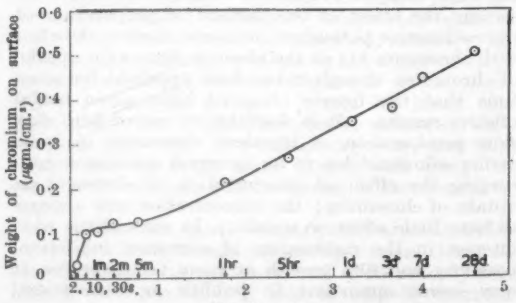

Fig. 2. Chromium uptake by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5. Specimens pre-exposed to air for 1 hr. (t_0 = time of immersion in minutes)

immersion of the iron or steel in the chromate solution, an adsorbed layer containing chromium ions is formed. This is followed by 'logarithmic' growth of an oxide film, with an adsorbed film always present. It is not possible, at this stage, to distinguish between the relative contributions, towards inhibition, of the adsorbed layer and the chromium-containing oxide film, since both are always present, though it is known that the longer the period of immersion, that is, the thicker the oxide film, the greater the degree of protection[1].

This work is continuing and will be described in detail elsewhere.

We thank Dr. Wormwell and other colleagues in the Corrosion and Radiochemical Groups for useful discussions, and the Radiochemical Group for estimating the radioactivity on the specimens. The work was carried out as part of the corrosion research programme of the Chemistry Research Board, and this communication is published by permission of the Director of the Chemical Research Laboratory, Department of Scientific and Industrial Research, and of the Office of the High Commissioner of India.

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BINDING IN HÆMOGLOBIN AZIDE AS DETERMINED BY ELECTRON RESONANCE

Electron Resonance Studies of Hæmoglobin Azide and Hydroxide Derivatives

PREVIOUS investigations[1,2] of the ionically bound acid-met- and fluoride hæmoglobin derivatives have shown that electron resonance methods are able to give very precise information concerning both the orientation of the hæm planes and also the binding of the iron atom to its immediate neighbours. We have now made a series of detailed measurements on the 'covalently bound' derivatives and some of the initial results are summarized here to illustrate the further information that can be deduced. The experiments have been carried out in the manner previously described[1], with radiation of frequencies of either 25,000 Mc./s. or 36,000 Mc./s. and at liquid hydrogen temperatures with the d.c. magnetic field rotated around the crystal under investigation.

If the iron atom is held with strong covalent d^2sp^3 octahedral bonds, two of the 3*d* orbitals will be used by bonding electrons and the five magnetic electrons of the ferric ion will be left with only the three remaining 3*d* orbitals to fill, and hence will pair in two of these leaving a single unpaired electron spin. In terms of the more precise molecular orbital picture, this is equivalent to a large splitting produced between the $d\gamma$ and $d\varepsilon$ levels (or, in Mulliken's notation, the e_g and t_{2g} levels respectively) of the 3*d* configuration, so that the five electrons will fill the $d_{xy}d_{yz}$ and d_{zx} orbitals of the t_{2g} group, and do not enter the e_g levels. The single unpaired spin should therefore produce one electronic transition per iron atom, from the lowest Kramers's doublet, with *g* factors spread across the free-spin value. From a detailed analysis (following communication) of these *g*-values it is then possible to deduce which of the t_{2g} levels is lying lowest, and to obtain some idea of what type of σ- or π-bonding is therefore to be associated with the iron atom (see the following communication).

Quite apart from this information on the chemical binding, further details on the structural symmetry of the surroundings of the iron atom can be obtained, since the variation in *g*-value no longer has axial symmetry, as in the ionic derivatives. Three mutually perpendicular axes are therefore individually defined by the results and these can then be correlated between different crystal forms to indicate equivalent directions within the hæm plane in different crystals. The results thus give information, not only on the orientation of the plane of the hæm group, but also on directions within the hæm group.

The azide derivative has been studied in most detail so far, and plots of the variation in *g*-value have been made for three perpendicular planes and for the plane of the hæm group in both type *A* and type *F* crystals[3]. Since the azide derivative can be obtained by converting the acid-methæmoglobin crystals *in situ*, it is very useful to take the conversion to only partial completion and study both spectra in the same crystal. The variation in *g*-value of the acid-methæmoglobin derivative can then be used as a very sensitive check on the orientation of the plane under investigation, the *g*-value remaining constant at 6·0 when the magnet is rotated around the hæm plane itself[1]. From a careful analysis of these results the variation in *g*-value of the azide derivative with respect to the hæm plane can be deduced, and this is shown in Fig. 1. The maximum value of 2·80 is in the direction of the hæm plane normal, with the other two axes lying in the hæm plane itself.

Theoretical analysis of these results shows that the d_{xy} orbital must be lying lowest in the t_{2g} group,

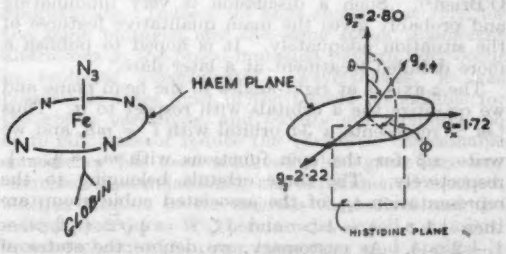

Fig. 1. The three principal axes of *g*-value variation for myoglobin and hæmoglobin azide

some 600–1,000 cm.$^{-1}$ below the d_{xz} orbital. This, in turn, lies about the same distance below the d_{yz} orbital. The latter separation may well be related to the less than fourfold symmetry imposed on the site by the histidine group of the globin. This is discussed in more detail in the following communication. The structural symmetry can be best expressed by quoting the g-value in the general direction (θ, φ), θ being the angle to the hæm normal and φ that between the axis of minimum g-value and the projection on to the hæm plane. Then: $g^2_{\theta,\varphi} = g^2_z \cos^2\theta + g^2_x \sin^2\theta \cos^2\varphi + g^2_y \sin^2\theta \sin^2\varphi = 7{\cdot}84 \cos^2\theta + 2{\cdot}96 \sin^2\theta \cos^2\varphi + 4{\cdot}93 \sin^2\theta \sin^2\varphi$.

A detailed analysis of the results from several other crystal types is now in hand, based on this equation, to deduce equivalent directions within the hæm plane for the different crystal types.

The myoglobin and hæmoglobin hydroxides are of particular interest, as on initial conversion from the acid-methæmoglobin derivative a g-value variation identical to that of the azide derivative is obtained. When the pH is increased, however, an entirely new electronic transition appears with a much larger variation in g-value, showing that a new type of chemical bond is formed at a certain pH value. Further work is in hand to elucidate the exact conditions at which this occurs. Other derivatives are also being studied so that a detailed picture of the molecular orbital patterns and symmetry of the surroundings of the iron atom can be obtained.

We would like to thank Dr. J. C. Kendrew, Dr. K. A. Munday and Thelma M. Haughton for a supply of large single crystals.

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Theory of Electron Resonance in Ferrihæmoglobin Azide

In the preceding communication, g-values were reported for ferrihæmoglobin azide. Here I give a theoretical interpretation of them, using the simplest plausible model for the five d electrons—that obtained by considering the matrix elements of the spin-orbit coupling, magnetic field energy and a rhombic distortion along the Cartesian axes within the six-dimensional manifold t^5_{2g} formed from pure $3d$ orbitals (see Howard[1], Stevens[2], Bleaney and O'Brien[3]). Such a discussion is very illuminating and probably gives the main qualitative features of the situation adequately. It is hoped to publish a more detailed treatment at a later date.

The z-axis is at right-angles to the hæm plane and we quantize the d orbitals with respect to it. Thus $|\, m >$ represents a $3d$ orbital with $l_z = m\hbar$, and we write α,β for the spin functions with $m_s = \frac{1}{2}, -\frac{1}{2}$, respectively. The three orbitals belonging to the representation t_{1g} of the associated cubic group are then $|\, 1 >$, $|\, -1 >$ and $|\, \zeta > = \frac{1}{\sqrt{2}}(|\, 2 > - |\, -2 >)$. As customary, we denote the states of the ground manifold by giving the quantum numbers of the electron missing from the t^6_{2g} closed shell. Thus $|\, 1\alpha >$ stands for $|\, 1\beta, -1\alpha, -1\beta, \zeta\alpha, \zeta\beta >$, etc. Then we suppose d_{zx}, d_{yz}, d_{xy} to have energies $-\frac{1}{2}V$, $\frac{1}{2}V$, Δ respectively (again these symbols all represent holes in t^6_{2g}, not single-electron functions). The spin-orbit energy is then $-\lambda\, \boldsymbol{l}.\boldsymbol{s}$ (with $\lambda > 0$) and we have two 3×3 matrices (see ref. 3) for determining the zero-field energies and eigenfunctions. The two matrices are conveniently combined in Table 1.

Table 1. Matrices for the Ground Manifold of Hæmoglobin Azide in Zero Magnetic Field

	$\lvert\, 1\alpha >$ (or $\lvert\, -1\beta >$)	$-\lvert\, \zeta\beta >$ (or $+\lvert\, \zeta\alpha >$)	$\lvert\, -1\alpha >$ (or $\lvert\, 1\beta >$)
$\lvert\, 1\alpha >$ (or $\lvert\, -1\beta >$)	$-\frac{1}{2}\lambda$	$\frac{1}{2}\lambda\sqrt{2}$	$\frac{1}{2}V$
$-\lvert\, \zeta\beta >$ (or $+\lvert\, \zeta\alpha >$)	$\frac{1}{2}\lambda\sqrt{2}$	Δ	—
$\lvert\, -1\alpha >$ (or $\lvert\, 1\beta >$)	$\frac{1}{2}V$	—	$\frac{1}{2}\lambda$

The ground doublet, then, must be of the form

$$\psi^+ = A\,|\, 1\alpha > + B\,|\, \zeta\beta > + C\,|\, -1\alpha >,$$
$$\psi^- = A\,|\, -1\beta > - B\,|\, \zeta\alpha > + C\,|\, 1\beta >,$$

with g-values

$$g_x = 2\,|\,(\sqrt{2}\,A + B)(\sqrt{2}\,C - B)\,|,$$
$$g_y = 2\,|\,(\sqrt{2}\,A + B)(\sqrt{2}\,C + B)\,|,$$
$$g_z = 2\,|\,|(2A^2 - B^2)\,|\ \text{(see ref. 2)}.$$

Without loss of generality we take A, B, C real and $(\sqrt{2}\,A + B)$ positive. Putting $p = \sqrt{2}\,A + B$ we readily find $g_x^2 + g_y^2 + g_z^2 = 4p^2\,(4 - p^2)$, whence, using the values observed by Gibson and Ingram, $\vec{g} = (1{\cdot}72, 2{\cdot}22, 2{\cdot}80)$, $p = 1{\cdot}504$ or $1{\cdot}319$. A simple way of obtaining A, B and C is to use these p and the observed g_z. Then there turn out to be just two solutions with $A^2 + B^2 + C^2 = 1$, one for each value of p. I give the resulting g-values in Table 2. It is clear that we should take $p = 1{\cdot}319$ and then the agreement with experiment is comparable with that obtained[3] by the same model for $K_3Fe(CN)_6$, and might be improved slightly by a more judicious fitting of parameters (the particular method of fitting adopted by Bleaney and O'Brien[3] gives worse agreement in our case, however).

Table 2. Calculated and Observed g-Values for Hæmoglobin Azide (g_z assumed)

	$p = 1{\cdot}504$	$p = 1{\cdot}319$	Observed
g_x	0·93	1·62	1·72
g_y	2·65	2·30	2·22
g_z	(2·80)	(2·80)	2·80

For $p = 1{\cdot}319$, it transpires that $(A, B, C) = (0{\cdot}842, 0{\cdot}128, 0{\cdot}525)$, and since these values give $\psi^{\pm}$ as eigenfunctions, we can work back and use the matrices shown in Table 1 to give us relations between the values of V, Δ and λ. Doing this, one obtains $V = -2{\cdot}26\ \lambda$, $\Delta = 3{\cdot}32\ \lambda$. Using the matrices of Table 1, we can then work out in terms of λ the relative positions of the three Kramers's doublets. The results are summed up in Fig. 1 with energies in terms of λ and, in brackets, in cm.$^{-1}$ assuming that $\lambda = 435$ cm.$^{-1}$ (from free-ion data; there is a possibility, however, that λ might be as low as about 280 cm.$^{-1}$, at least in $K_3Fe(CN)_6$ (see ref. 3)).

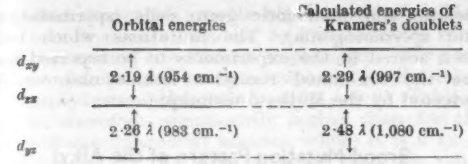

Fig. 1. Energies in hæmoglobin azide derived from observed g-values (d-functions are holes in t_{2g}^6)

Fig. 1 refers to holes in the t_{2g}^6 shell and so, for one-electron functions, we have the result that adjacent pairs of the three functions (d_{xy}, d_{zx}, d_{yz}) are separated by approximately equal amounts (of some 600–1,000 cm.$^{-1}$) and with d_{xy} lying lowest. This is remarkably interesting, for one might have expected the reverse to be true, on the grounds that d_{xy} cannot π-bond appreciably with any of the groups ligated to the iron, but d_{zx} and d_{yz} can π-bond with the porphyrin ring, and probably, at least for one of them, with the other ligands attached to the iron. Then should not d_{xy} be the least rather than the most stable ?

I cannot go into this problem in detail here, but point out that the anomalous result may be, at least in part, due to the d_{xy} orbital being fairly well away from the directions in which the negative charge of the ligands is mainly concentrated. In the plane of the hæm the nitrogen electrons which are not σ-bonding with Fe are tied up in the N—C σ-bonds. However, out of the plane of the hæm the nitrogen π-electrons are probably on the whole closer to the iron atom. Of course, I realize that the N—C σ-bonds also can be combined to give an orbital around the nitrogen atom of π-type with respect to the Fe—N bond—I suggest, however, that there may be a larger electron density π to the porphyrin plane (see ref. 4) and also that the N—C σ-bonds contract slightly under the influence of the carbon nuclear charge so that the π-type nitrogen orbital obtained from them is not pure $2p\pi$.

With such an interpretation one would say that the total effect of π-interaction in this case is to raise the energy of the interacting d-orbitals. If so, then it may be that the least stable orbital, d_{yz}, is that which is the most exposed to π-interaction and therefore if there is an iminazole ring attached to the iron atom it lies in the xz plane. Another way of putting this is to say that the direction of the smallest g-value lies along the orthogonal projection of the plane of the iminazole ring on the hæm plane. I emphasize that this final deduction is very tentative indeed and is really only inserted to provoke discussion. It does, however, underline that electron resonance and its interpretation afford a possibility of finding even such intimate details of the environment of the iron atom as the orientation of the, at present hypothetical, iminazole ring.

I am greatly indebted to J. F. Gibson and D. J. E. Ingram for making the experimental data discussed here available to me prior to its publication.

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MUTAGENIC RESPONSE TO THE ALKYL-METHANESULPHONATES DURING SPERMATOGENESIS IN *DROSOPHILA MELANOGASTER*

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Introduction

THE degree of genetic damage induced by a given dose of a mutagen in a cell population undergoing differentiation varies with the cell stage at the time of treatment. Thus when an adult *Drosophila* male is injected with a single dose of a chemical mutagen and then its germ line is fractionated by repeated matings to successive virgin females, the mutation-rate shows significant variations in the successive broods[1–3]. Since the sperm used in the successive matings must have been derived from progressively younger germ cells at the time of treatment, the fluctuations in the mutation-rate have been attributed to differential genetic response of the stages of spermatogenesis to the action of the mutagen. In this communication it is intended to analyse this pattern of genetic response to the action of different alkyl-methanesulphonates, and to reveal how far this analysis helps in the elucidation of the mechanism of mutagenesis.

Brood Technique and Cell-Stage Utilization

The testis of an adult *Drosophila* male presents an uninterrupted spectrum of differentiation from spermatogonia through spermatocytes and spermatids to mature sperm[2]. Any attempt at fractionating this continuous germ line into separate cell stages by repeated matings is bound to be very rough and approximate. Indeed, we have shown that even for the same mutagen and the same strain, significant alterations in the brood-mutation pattern may occur in replicate experiments[3]. Nevertheless, it was possible to trace most of the factors responsible for the above variations, and modify our technique so as to eliminate or reduce the variables. Reasonable consistency has been achieved when great care was exercised in standardizing the experimental method, both in relation to the animals themselves and the mating procedure. We therefore developed a standard brood technique[2,3] in our laboratory and applied it for all the mutagens investigated. The males used

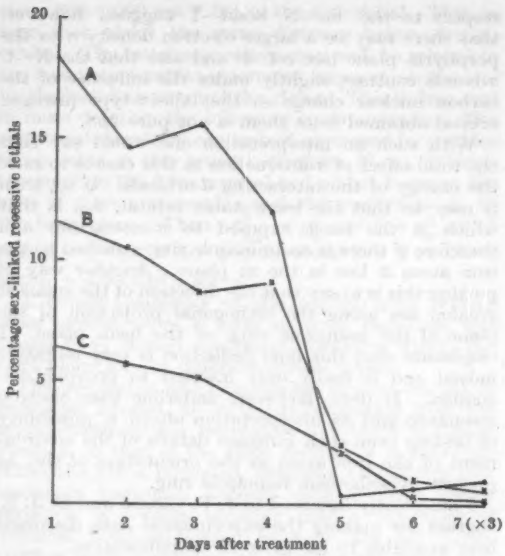

Fig. 1. Sex-linked recessive lethals in successive broods for ethyl methanesulphonate (curve *A*), and methyl methanesulphonate (curves *B* and *C*); based on data in Table 1

were from the Oregon-*K* stock and were selected at an age of 30±5 hr., and weighed 0·85±0·05 mgm. The compound under test was dissolved in isotonic saline (0·4 per cent sodium chloride) and injected intra-abdominally around the testes. The concentration injected was as a rule well below the *L.D.*50-level. Each male received practically the same volume of solution, which was 0·25±0·05 µl. The treated males were always mated 24 hr. after injection so as to allow the flies to regain their vigour and activity. The fractionation of the progeny into broods was undertaken by repeated matings to 3-day-old females every three days (calculated from the day of treatment), either in pair cultures, or in mass cultures with a sex-ratio of unity. The cultures were kept at a constant temperature of 25±1° C. Under such conditions, it has been shown[2,3] that sperm ejaculated in the first four matings (4 broods: 12 days after treatment) has been derived from post-meiotic germ cells (sperm and spermatids), whereas sperm utilized in later matings (5th brood onwards: more than 12 days after treatment) has been derived from meiotic and premeiotic germ cells (spermatocytes and spermatogonia). The mutations which have been scored in the experiments to be reported here are the sex-linked recessive lethals and visibles detected by the Muller-5 technique.

Brood-Mutation Pattern of the Alkyl Methanesulphonates

The mutation yield of the various stages of spermatogenesis under the effect of ethyl methanesulphonate (*C.B.* 1528: $CH_3CH_2OSO_2CH_3$) and methyl methanesulphonate (*C.B.* 1540: $CH_3OSO_2CH_3$) has been investigated by our standard brood technique and the results are summarized in Table 1 and Fig. 1. There is a convincing similarity in the brood-mutation pattern of the two sulphonates presented. The general tendency is that the mutation-rate decreases the later the brood. At the higher doses for both compounds (curves *A* and *B*, Fig. 1), and in spite of the non-significant fluctuations in the first four broods, a gradual fall in the mutation-rate is clearly discernible. This fall then proceeds at a much sharper gradient from the fourth to the fifth brood, and the low mutation-rate thus reached is maintained to the end of the experiment at the seventh brood. At the lower dose of the methyl ester (curve *C*, Fig. 1) the fall in the mutation-rate is gradual and almost linear from the first to the seventh broods. The decrease in the mutation-rate the later the brood (and, therefore, the younger the germ cell at the time of treatment) has already been ascertained also for the di-(methanesulphonoxy)alkanes[4]. It is, therefore, certain that the above general trend is characteristic of the various compounds of the alkyl methanesulphonate series, irrespective of whether the molecule is mono- or di-functional as regards the sulphonoxy groups.

From the above brood-mutation pattern, and from previous considerations as regards the speed of utilization of the stages of the germ line in our standard brood technique, the following conclusion emerges. The alkyl methanesulphonates are most active on the later stages of spermatogenesis (sperm and latest spermatids); the response decreases the earlier the stage of germ cell differentiation, almost reaching the control level among the earliest germ cells, the spermatogonia.

The yield of the sex-linked recessive visibles in the successive broods under the effect of the alkyl methanesulphonates follows essentially the same trend as the lethals (Table 1). Likewise, the sperm

Table 1. Sex-linked Recessive Visibles and Lethals induced in the Successive Broods under the Effect of the Ethyl and Methyl Esters of Methanesulphonic Acid

Compound	Ethyl methanesulphonate					Methyl methanesulphonate								
Concentration injected	1·61 × 10⁻² *M*					0·25 × 10⁻² *M*					0·45 × 10⁻² *M*			
Brood	Chromosomes tested	Visibles No.	Visibles %	Lethals No.	Lethals %	Chromosomes tested	Visibles No.	Visibles %	Lethals No.	Lethals %	Chromosomes tested	Visibles No.	Visibles %	Lethals No.	Lethals %
1	485	23	5·0	84	18·3	509	13	2·6	32	6·3	455	21	4·6	53	11·6
2	350	13	3·7	51	14·6	473	8	1·7	27	5·7	506	12	2·4	53	10·5
3	301	17	5·6	47	15·6	504	2	0·4	26	5·2	677	15	2·2	59	8·7
4	383	9	2·3	46	12·0	487	2	0·4	19	3·9	482	9	1·9	44	9·1
5	316	—	—	1	0·3	481	—	—	10	2·1	494	2	0·4	12	2·4
6	345	1	0·3	2	0·6	576	—	—	2	0·3	493	1	0·2	5	1·0
7	328	—	—	3	0·9	511	—	—	1	0·2	326	—	—	2	0·6
Total	2 481	63	2·5	234	9·4	3,541	25	0·7	117	3·3	3,433	60	1·7	228	6·6
Ratio visibles/lethals	0·27					0·21					0·26				

and latest spermatids give the highest yield of visibles. The overall ratio of visibles to lethals shows some variation among the various sulphonates. For both the mono-functional methanesulphonates (the ethyl and methyl esters) this ratio is $0{\cdot}26 \pm 0{\cdot}01$ (Table 1) and is, therefore, significantly higher than for the di-(methanesulphonoxy) alkanes, where it is $0{\cdot}12 \pm 0{\cdot}02$ (see ref. 5). It is to be noted that this ratio, even for the mono-methanesulphonates, is lower than that for 2-chloroethyl methanesulphonate (C.B. 1506), which gives an overall ratio of $0{\cdot}42 \pm 0{\cdot}02$ (see ref. 6).

Mechanism of Mutagenesis under the Alkyl Methanesulphonates

In a recent communication[6] we directed attention to the fact that for 2-chloroethyl methanesulphonate, the highest mutagenic response was in the very early germ cells (utilized more than 12 days after treatment), and the lowest was in mature sperm. This is the reverse situation to that produced with ethyl methanesulphonate, or indeed any other mono- or di-methanesulphonate so far investigated in our laboratory, where the maximal effect is on the later germ cells. By way of illustration we have given in Fig. 2 the actual experimental curve for the brood/mutation-rate under the effect of ethyl methanesulphonate (curve *A*, based on Table 1) and compared it to that for roughly the same injected molar concentration of the chloroethyl ester (curve *D*, based on the previously published data[6]).

From the chemical point of view, both ethyl and 2-chloroethyl methanesulphonate are potential alkylating agents, but the chemical reactivity of the sulphonoxy group is much higher in the former compound. The data of Davis and Ross[7] show that *in vitro* the hydrolysis constants for the sulphonoxy groups in water expressed as $k \times 10^{-7}$ sec.$^{-1}$ at 37° C. are: 164·8 for the ethyl ester, as compared to 2·4 for the chloroethyl ester, giving a ratio of 68·7 : 1. Expressed in another way, nearly 27 per cent of ethyl methanesulphonate is hydrolysed in water at 37° in 5½ hr., whereas only 20 per cent of the chloroethyl ester is hydrolysed under the same conditions in 10 days; the chlorine atom is not appreciably hydrolysed under the above conditions. While it is fully realized that *in vivo* the relative reactivity of the two sulphonates may be different, due to differential excretion, detoxication and other biochemical factors, yet it is virtually certain that 2-chloroethyl methanesulphonate is retained in the living tissue in an active (unhydrolysed) state for much longer than ethyl methanesulphonate.

The above difference in the chemical reactivity of the two sulphonates may explain some of the differences in their brood-mutation patterns (Fig. 2). The much higher mutation-rate induced in the sperm by ethyl methanesulphonate (as compared with the chloroethyl ester) could be associated with the higher chemical reactivity of its sulphonoxy group. Furthermore, due to this higher reactivity, the intra-cellular residue, which is not used up in the alkylation of the cell constituents, almost certainly becomes inactivated (by hydrolysis) before the first sperm sample is drawn in the first mating (within three days after treatment). The mutation-rate detected in the successive broods would then represent the response of the genetic material of the various cell stages for roughly the same time of treatment. 2-Chloroethyl methanesulphonate, on the other hand, because of its lower

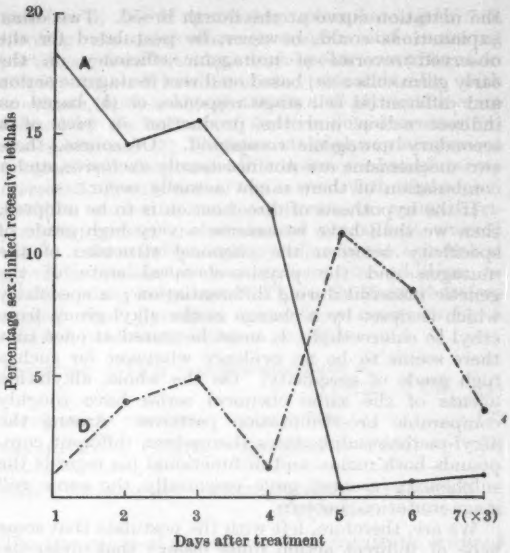

Fig. 2. Comparison of the brood-mutation patterns (sex-linked recessive lethal rate) for ethyl methanesulphonate (curve *A*, conc. $1{\cdot}6 \times 10^{-2}$ *M*, Table 1) and 2-chloroethyl methanesulphonate (curve *D*, conc. $1{\cdot}4 \times 10^{-2}$ *M*, data in ref. 7)

reactivity and hydrolysis-rate, may be retained within some cells in an active form for several days, at least for more than the 3-day period of one brood. In such circumstances, the biological activity would be expected to rise as a function of the time-concentration product, and it would be feasible to arrive at a situation where the mutation-rate would increase with the time after treatment, which is roughly what was found experimentally for the first three broods. From the third to the fourth brood, however, there is a significant drop in the mutation-rate. A four-fold statistical test for this drop (illustrated in Fig. 2; for data see Table 1, dose $1{\cdot}4 \times 10^{-2}$ *M*, ref. 6) gave $\chi^2 = 4{\cdot}05$, $D.F. = 1$, $P = 0{\cdot}046$. This trough in the mutation curve at the fourth brood under the effect of the chloroethyl ester probably indicates the end of the influence of the intra-cellular 'residual' compound. If such an active compound was retained throughout the differentiation of the cells utilized in the fourth brood, they would be expected to yield a higher (or at least the same) mutation-rate as those recovered in the third brood, rather than a lower rate as observed. It seems, therefore, that no appreciable amount of active 'residual' sulphonate remains in the germ cells more than 9 days after treatment.

The most outstanding difference in the brood pattern of ethyl methanesulphonate as compared to the chloroethyl ester lies in the response of the early germ cells utilized later than the fourth brood. Whereas with the latter compound there is a sharp rise from the fourth to the fifth brood followed by the retention of a fairly high mutation-rate in later broods, the ethyl ester gives the exact opposite—a sharp drop from the fourth to the fifth brood and then a sustained low mutation-rate. The high mutation yield from the fifth brood under the effect of 2-chloroethyl methanesulphonate is probably not a function of time (that is, longer period of reaction between intra-cellular compound and the cell constituents), because of the presence of the trough in

the mutation curve at the fourth brood. Two other explanations could, however, be postulated for the observed reversal of mutagenic efficiency on the early germ cells: (*a*) based on direct mutagenic action and differential cell stage response, or (*b*) based on indirect action and the production *in vivo* of a secondary mutagenic compound. Of course, these two mechanisms are not necessarily exclusive, and a combination of them might actually occur.

If the hypothesis of direct action is to be adopted, then we shall have to assume a very high grade of specificity between the chemical structure of the mutagen and the physico-chemical state of the genetic material during differentiation; a specificity which is upset by a change in the alkyl group from ethyl to chloroethyl. It must be stated at once that there seems to be no evidence whatever for such a high grade of specificity. On the whole, alkylating agents of the same chemical series have roughly comparable brood-mutation patterns. Among the alkyl-methanesulphonates themselves, different compounds both mono- and di-functional (as regards the sulphonoxy groups) gave essentially the same cell stage-mutation pattern.

We are, therefore, left with the postulate that some type of indirect action must occur; that under the effect of 2-chloroethyl methanesulphonate some 'secondary mutagen' is produced *in vivo* which is most active on the early germ cells and which is not formed from other alkyl methanesulphonates, including the ethyl ester. Evidence for the setting in of mutagenesis through indirect action under the effect of the chloroethyl ester is not entirely lacking. Unlike the other sulphonates it gives a mutation-rate which increases with dose only for the later germ cells (utilized in the first three broods), while for the earlier ones (utilized in the fourth–seventh broods) there is no direct relationship between the dose administered and the mutation yield.

The time of production of the secondary mutagen is not difficult to deduce. The peak of maximal mutability attributed to this agent occurred in the sperm sample utilized in the fifth brood. It is in this sperm sample also that the first 'visible' clusters appear, indicating that this sperm must have been derived from the latest germ cells which were capable of multiplication, after mutating by the treatment. This means that the germ cells most responsive to the action of the secondary mutagen are the latest spermatogonia, just before they start metamorphosing to spermatocytes. Now, it is known that under our experimental conditions spermatogonia differentiate into mature sperm within a period of 15 days[2]. It follows, therefore, that the lag in the detection of the genetic effects of the secondary mutagen can be entirely accounted for on the basis of the time needed for the responsive cells to complete differentiation. In other words the secondary mutagen must have been formed, and produced its effect, almost immediately after the injection of the chloroethyl ester.

As to the chemical nature of the secondary mutagen, the results of Roberts and Warwick[8] using ^{14}C-ethyl methanesulphonate (labelled on the α-carbon atom) are most relevant. Evidence has been obtained that this sulphonate alkylates the —SH group of cysteine. It is likely that the effect of 2-chloroethyl methanesulphonate under *in vivo* conditions is comparable to that of the ethyl ester, in which case the reaction product would not be S-ethyl cysteine, but its chloroethyl analogue.

Chloroethyl cysteine has been synthesized in the Chemistry Department of this Institute and will be analysed for mutagenicity, to determine whether it gives a brood-mutation pattern of the type yielded by 2-chloroethyl methanesulphonate. Nevertheless, even at this stage, it may be stated that the genetical properties of the chloroethyl ester are not incompatible with the possibility that an amino-acid-mustard is produced *in vivo*. Recent work on the mutagenicity of the 'N-mustard' derivatives of phenylalanine shows that there are some features of its biological mode of action which are comparable to those brought about by 2-chloroethyl methanesulphonate. They are similar in so far as they produce high cytotoxic and mutagenic activity on the early germ cells—that is, among the premeiotic stages. Another comparable feature is that the phenylalanine mustard (particularly the *L*-derivative) yields a high ratio of visibles to lethals, which though not as high as for the chloroethyl ester, is nevertheless the nearest to it among the 'mustards' so far analysed[5,6].

To test the hypothesis of indirect action (through a metabolite) under the effect of 2-chloroethyl methanesulphonate we examined the brood-mutation pattern for fluoroethyl methanesulphonate (*C.B.* 1522, $FCH_2CH_2OSO_2CH_3$). This latter compound has the same low chemical reactivity (same hydrolysis-rate) as the chloroethyl ester, but would not be expected to produce *in vivo* a highly reactive 'mustard'. The mutation peak at the fifth brood which occurred with the chloroethyl ester, and which has been attributed to a strong secondary mutagen (presumably a 'mustard') would not, therefore, occur with the fluoroethyl ester. The genetical results so far obtained (to be detailed elsewhere) conformed with the biochemical expectation. Under the effect of fluoroethyl methanesulphonate the mutation-rate increased for the first three broods (reaching roughly half the rate induced by the same molar concentration of the chloroethyl ester) and then levelled off into a plateau until the seventh brood. There can scarcely be any doubt, therefore, that the high mutagenic response of the early germ cells under the effect of 2-chloroethyl methanesulphonate is an indication of the formation of a secondary, highly active mutagen. An attractive property of this mutagen is its potency in the induction of 'visibles'. It is, therefore, hoped that its successful identification and synthesis might well provide us with an agent highly selective for the induction of this class of mutation.

We wish to thank Prof. A. Haddow, Prof. F. Bergel and Dr. W. C. J. Ross for their interest and suggestions, and our other colleagues of the Chemistry Department of this Institute for their helpful discussion as well as the supply of the mutagens.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Mechanism of Conversion of Fat to Carbohydrate in Castor Beans

THE mechanism of the interconversion of fat and carbohydrate, known to occur in germinating fatty seedlings, has not yet been established. It has been shown that the castor bean can utilize acetate carbons in the synthesis of sucrose, and that the labelling of the sugar after incubation of bean extracts with sodium acetate-^{14}C is consistent with the operations of glycolysis and the tricarboxylic acid cycle[1]. Yet these reactions are not by themselves sufficient to account for any net synthesis of carbohydrate from fat, but necessitate the occurrence of ancillary replacement reactions, whereby the intermediates drained from the cycle could be replaced directly by the breakdown of fatty acids. The 'glyoxylate by-pass' of the tricarboxylic acid cycle demonstrated in acetate-grown *Pseudomonas*[2] supplies such a replacement mechanism, which would also account for the observed labelling patterns. It was of interest, therefore, to investigate the possible occurrence of this by-pass in castor beans, particularly since malate is one of the earliest labelled products formed from labelled acetate in this tissue.

Cell-free extracts of the endosperm and cotyledons of castor bean seedlings four to five days old were prepared by macerating the beans in a Waring blendor in 0·1 *M* potassium phosphate, *p*H 7·5, filtering the juice through muslin and removing particles from it by high-speed centrifugation (25,000 *g*). When incubated anaerobically with *iso*citrate, both α-ketoglutarate and glyoxylate were formed by the actions of *iso*citric dehydrogenase (1) and *iso*citritase[3] (2). The amounts of glyoxylate present progressively decreased while those of α-ketoglutarate increased. Incubation of the extract with triphosphopyridine nucleotide and *iso*citrate, or reduced triphosphopyridine nucleotide and glyoxylate, showed that a reduced triphosphopyridine nucleotide-linked glyoxylic reductase was present in addition to *iso*citric dehydrogenase. These findings therefore suggest that glycollate arises from *iso*citrate by a coupled oxidation-reduction reaction:

*Iso*citrate + TPN → α-ketoglutarate + $TPNH_2$ + CO_2 (1)

*Iso*citrate → succinate + glyoxylate (2)

Glyoxylate + $TPNH_2$ → glycollate + TPN (3)

Sum: 2 *Iso*citrate → α-ketoglutarate + succinate + glycollate + CO_2 (4)

The formation of glyoxylate from *iso*citrate, without concomitant formation of α-ketoglutarate, was demonstrated in partially purified extracts (Fig. 1). Extract from 1 gm. of beans catalysed the formation of at least 8 μmoles of glyoxylate/hr.

When cell-free extracts were incubated with *iso*citrate, ^{14}C-labelled acetate, coenzyme *A*, glutathione and adenosine triphosphate, malate was the only labelled compound formed. There was no incorporation of carbon-14 from acetate in the absence of adenosine triphosphate or *iso*citrate (Table 1).

Fig. 1. Formation of glyoxylate from *iso*citrate by partially purified (0–30 per cent ammonium sulphate fraction) castor bean extract.
The α-keto compounds formed on incubation of extract with *iso*citrate were isolated as the 2,4-dinitrophenylhydrazones and analysed by paper partition chromatography (ref. 5). Derivatives of authentic α-ketoglutarate, pyruvate and glyoxylate were simultaneously analysed as standards. No detectable α-keto compounds were formed in the absence of *iso*citrate, or from *iso*citrate by boiled extract

Table 1. FORMATION OF LABELLED MALATE FROM ^{14}C-ACETATE
The complete system contained 100 μmoles of potassium phosphate *p*H 7·6, 10 μmoles of glutathione, 10 μmoles of magnesium chloride, 0·08 μmole of coenzyme *A*, 0·1 ml. of cell-free bean extract, 10 μmoles of *iso*citrate, 6 μmoles of adenosine triphosphate, 2 μmoles of sodium acetate-^{14}C (giving 7·4 × 10^5 counts/min. under the conditions of radioassay used) and water to final volume of 1 ml., incubated at 30° for 15 min. Samples were analysed by two-dimensional chromatography and autoradiography.

System	Radioactivity of malate (counts/min.)
Complete system	5,500
No adenosine triphosphate	309
No *iso*citrate	510

This production of malate from acetate and *iso*citrate (7), catalysed by *iso*citritase (2) and malate synthetase[4] (6), is the overall reaction of the glyoxylate by-pass. These results therefore indicate that the glyoxylate by-pass operates in castor beans, and provides both a route for the interconversion of fat and carbohydrate and information on the origin of glycollic acid in this tissue.

*Iso*citrate → succinate + glyoxylate (2)

Acetate + ATP + CoA → acetyl CoA + (AMP + PP) (5)

Acetyl CoA + glyoxylate → malate (+ CoA) (6)

Sum: *Iso*citrate + acetate → malate + succinate (7)

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Effect of Day-length and Gibberellic Acid on the Flowering of *Arabidopsis*

It has recently been discovered[1] that a mixture of gibberellin *A* and gibberellic acid greatly accelerates the initiation of flowers in unvernalized *Hyoscyamus niger* L., a vernalizable long-day biennial plant. Even more recently, it has been found[2] that this mixture of compounds will cause flower formation under short-day conditions in *Bryophyllum crenatum* Baker, a plant which requires long-day for internode elongation, short day for floral initiation, and long day again for the development of functional flowers[3].

With *Arabidopsis thaliana* (L) Heynh., a facultative long-day plant[4], pilot experiments have established that gibberellic acid will accelerate flower formation in non-vernalizable 'races' grown under short-day, and in non-vernalized, but vernalizable, 'races' grown under long-day conditions.

The data reported here were obtained with the rapidly growing race, Estland, which does not respond to vernalization. The experimental plants were grown on agar in 16 mm. × 150 mm. test-tubes under aseptic conditions, as described elsewhere[5]. They were grown under fluorescent light of about 900 foot-candles intensity at 23–25° C. in two growth chambers, one with 8 hr. light per day and the other with continuous light. When the plants under short-day were 19 days old, aliquots of Seitz-filtered gibberellic acid solution were added aseptically to half of them, to give 4 μgm. of gibberellic acid per plant. Plants under long day received 0, 1, 2, 4 and 8 μgm. per plant when 8 days old. Approximately ten plants were provided for each treatment. A plant was considered to be flowering when the first flower opened.

Table 1. The Effect on Flowering and Leaf Number of Day-length and Gibberellic Acid (G.A.)

Day-length (hr.)	Treatment	No. of plants	No. of rosette leaves	No. of cauline leaves	Days to flowering
8	Nil	9	12·2±0·1	8·9±0·3	67·6±0·5
	4 μgm. G.A. per plant	10	8·3±0·4	8·5±0·3	50·5±0·5
24	Nil	9	7·6±0·2	3·5±0·2	21·8±0·4
	4 μgm. G.A. per plant	10	6·2±0·2	4·2±0·2	20·5±0·4

Fig. 1. *Arabidopsis thaliana*. Plants 47 days old, grown in 8-hr. day. Left, control; right, with 4 μgm. of gibberellic acid

Table 1 shows that there is a highly significant ($P < 0.001$) acceleration of flowering when plants are treated with gibberellic acid and grown under an 8-hr. day (Fig. 1). A more complete replacement of day-length might be obtained by applying gibberellic acid more frequently. The presence of an interaction ($P < 0.005$) between day-length and gibberellic acid is confirmed by the ability of the compound significantly ($P < 0.05$) to decrease the time required for flowering under long day. This effect cannot be due to a partial replacement of a vernalization requirement as in *Hyoscyamus*, for the mean time to flowering with seed vernalization (21 days at 5° C.) was 23·3 ± 0·4 days; with vernalization plus gibberellic acid, the time was 22·0 ± 0·5 days.

Table 2. The Effect on Flowering under Long-Day of a Geometric Concentration Range of Gibberellic Acid

Gibberellic acid per plant (μgm.)	No. of plants	Days to flowering
0	9	21·8 ± 0·4
1	10	21·0 ± 0·6
2	10	19·7 ± 0·4
4	10	20·5 ± 0·4
8	5	23·8 ± 0·9

An analysis of variance of the data shown in Table 2 yields a highly significant ($P < 0.01$) F ratio for differences between treatment means. Individual t tests indicate a highly significant ($P < 0.01$) acceleration of flowering with 2 μgm. of gibberellic acid per plant and a significant ($P < 0.05$) inhibition of flowering with 8 μgm. per plant. With the latter treatment four plants became distorted, their apical meristems were damaged, and their flowering was much delayed; they were not included in the analysis.

Gibberellic acid is the first substance found that appears likely to be generally effective in promoting flowering. However, its effects on the long–short-day plant, *Bryophyllum*, and the facultative long-day plant, *Arabidopsis*, are in the nature of accelerations

of flowering, and it remains to be seen if it will cause flower formation in an obligate long-day plant.

I thank Dr. P. W. Brian, of Imperial Chemical Industries, Ltd., Welwyn, England, for the gift of the gibberellic acid used in these experiments.

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Metabolism of Acetate in *Hevea brasiliensis*

THERE is now considerable evidence to show that the synthesis of *iso*prenoid compounds in both plants and animals may proceed by the utilization of acetate as the sole primary carbon source[1,2], and that the pathways by which the *iso*prenoid monomer is derived from acetate may have a number of carboxylate intermediates in common, for example, ββ′-dimethyl acrylate and β-hydroxy-β-methyl glutarate[1,3]. Before taking part in these metabolic reactions acetate first undergoes activation by coupling with coenzyme *A*, and this form of carboxyl activation is then transmitted through subsequent intermediates arising from acetate. An examination of the latex and tissues of *Hevea brasiliensis* for such activation systems is briefly reported here.

Freeze-dried serum, obtained from fresh latex which had been kept at −20° for 3 weeks, was used in much of the work. Samples of freeze-dried 'yellow-fraction' (the yellow sediment obtained by centrifuging fresh latex at high speed) were also tested. Tissue samples were derived either from young seedlings grown in a greenhouse, or from fresh fragments of the cambial layer of mature trees. These fragments were packed in polythene sachets surrounded by 'dry ice', and transported from Malaya in Dewar flasks. This method has been generally useful in the preservation of cellular enzyme systems.

Hydroxylamine was used as a trapping reagent for activated carboxyl compounds in an assay system similar to that described by Beinert *et al.*[4]. Water-soluble hydroxamates were determined as the red ferric complexes by the method of Kornberg and Pricer[5]. Hydroxamate extracts were prepared for chromatography by adding an equal volume of ethanol to portions (2–5 ml.) of the incubation mixture, and evaporating the filtrate to dryness under reduced pressure. The dry residue was extracted with warm ethanol (0·5 ml.), and spots analysed on Whatman No. 1 paper with a solvent system composed of *n*-butanol/water/acetic acid (63 : 27 : 10 by vol.)[6].

Carboxyl activation was detected in freeze-dried serum one month after its preparation, hydroxamates being produced in incubation mixtures to which no acetate, adenosine triphosphate, or coenzyme *A* had been added. Addition of adenosine triphosphate and coenzyme *A* did not stimulate this inherent activity, but when extra acetate (10 μmoles) was supplied more hydroxamate was produced, and this reaction could be further increased by the addition of adenosine triphosphate (7 μmoles), but not of coenzyme *A*. Activity was not detected in boiled serum, and rapidly decayed in solutions kept at room temperature. The dried serum powders were also very unstable in storage at 0° C., the activity falling by a half during the second month after preparation.

Chromatography of the hydroxamates resulted in three spots, that with R_F value 0·48 being markedly increased by the addition of acetate to incubation mixtures, and corresponding exactly with authentic acethydroxamic acid. The remaining spots with R_F values 0·67 and 0·81 were not positively identified.

Attempts to detect free acid intermediates of *iso*prenoid synthesis suggested that much of the acetate administered to latex was directed towards respiratory metabolism. General increases were observed for acids of the Krebs cycle, and more particularly for succinic and fumaric acids. However, it should be mentioned that these two acids, under the different chromatographic conditions employed, behaved identically with two possible *iso*prenoid intermediates, namely, β-hydroxy-β-methyl glutaric and β-methyl glutaconic acids, respectively, so that the possibility of mixtures could not be ruled out.

In most samples of freeze-dried yellow-fraction, carboxyl activation was barely detectable, but in a few cases the activity approached that of a comparable amount of whole serum. This suggests that the yellow-fraction particles may be important loci of carboxyl-activating systems.

The greatest difficulty in the use of cambial tissue for experiment was due to the high concentration of tannins present. No soluble protein could be extracted at *p*H values lower than 8·5, and carboxyl activation was not detected in homogenates. After grinding with sand in *tris* buffer of *p*H 9·2 (0·05 *M*), and washing with fresh buffer, the homogenates were active, and some inactive protein could be extracted by magnesium sulphate solution (¼ sat.). The activity was associated entirely with the bulky cell debris, every attempt to obtain soluble systems being unsuccessful.

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A Technique for the Measurement of Lead Tolerance in Plants

BRADSHAW reported[1] that root growth was inhibited when plants of *Agrostis tenuis* were grown in soil from the tip of an old Welsh lead mine, while plants originally growing on the tip produced normal roots. This suggested that some plants of *A. tenuis* were inherently more tolerant of the lead and zinc in the soil than others. On similar waste tips in Scotland, *A. tenuis* is replaced by *Festuca ovina* and *Deschampsia flexuosa*, and a method has been worked

out for the measurement of lead tolerance in *F. ovina* from soils of different lead contents.

In preliminary experiments it was found that the toxicity of lead was greatly reduced by the presence of other salts. 3 p.p.m. of lead in the form of a pure solution of lead nitrate was highly toxic to all plants of *F. ovina*, while in a Knopp's culture solution (without phosphate because of the extreme insolubility of lead phosphate) many plants showed little reduction in root growth at 25 p.p.m. The salts used for making up the culture solution were then tested one at a time, and the only one which had any antagonistic effect to lead was calcium nitrate. It seemed of interest to find out whether the calcium or the nitrate ion was responsible.

Tillers of a single plant of *F. ovina* were rooted in water and then transferred to solutions of calcium nitrate, calcium chloride and sodium nitrate of equivalent concentrations. Lead nitrate and zinc sulphate were added gradually to two sets of cultures, so that the tillers were transferred each day one step up the series: 0, 1, 3, 10, 30, 100 p.p.m. of the metal, the concentrations of the accompanying salts being kept constant. The length of the longest root on each tiller was measured at each transfer and the amounts of growth in the different solutions compared. The two metals gave rather different results. In the case of lead, growth fell off very rapidly with increasing concentration in the presence of sodium nitrate, but in presence of calcium nitrate or calcium chloride growth was increased at low concentrations and only fell markedly at 30 p.p.m. and more. The calcium ion was clearly reducing the toxicity of the lead, while the nitrate ion had no such effect. In the case of zinc there was no stimulation at low concentrations and little sign of reduced toxicity in the presence of any of the three salts.

It was decided to use 1 gm./litre of calcium nitrate in all subsequent experiments so that higher concentrations of lead could be used without stopping all growth. The exact adjustment of the lead concentration would then be less critical, and slight loss by precipitation or adsorption less serious. It remained to find the most suitable concentration of lead for showing up possible differences between plants.

Five plants of *F. ovina* from different habitats were tillered and rooted in calcium nitrate. The rate of root growth in this solution was measured and found to vary little from one plant to another. The rate of growth was measured again after the addition of different concentrations of lead nitrate (Table 1).

It will be seen from Table 1 that the first differences between plants began to show when the lead concentration reached 10 p.p.m. Root growth in plants 140 and 197 was slowed down while plants 127, 154 and 191 were unaffected. It was satisfactory to note that the last three plants came from poisonous lead tips, 197 came from an old overgrown tip and 140 came from a hillside away from the mining area. At 30 p.p.m. the difference was more marked, the two intolerant plants being able to grow very little while the other three were slowed down slightly. At 100 p.p.m. very little growth took place in any of the plants.

Table 1. Rates of Root Growth (2-day Increments in mm.)

Lead added		0	3	10	30	100 p.p.m.
Plants:	127	19	18	13	11	4·0
	140	17	14	8	2·5	0·5
	154	24	22	14	11	2·0
	191	23	17	20	16	2·0
	197	21	19	9	3·8	3·0

For the routine testing of large numbers of plants a concentration of 25 p.p.m. of lead was eventually chosen, as this allowed a little growth in the least tolerant plants but still produced a slight check in that of the most tolerant. When the roots have reached a constant rate of growth, that rate is measured in calcium nitrate alone, and the amount of growth is again measured four days after the addition of lead nitrate. An index of lead tolerance is derived from these two growth-rates. The whole experiment is carried out at a temperature of 70° C. and with constant artificial light of about 500 foot-candles intensity.

A good range of responses is obtained from different plants, and it is already clear that those from any one tip tend to be similar. There is a reasonable correlation between the mean index for a tip and the amount of lead which can be extracted with 0·5 *N* acetic acid from the soil of that tip.

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Action of Gonadotrophins on the Ovary

It is generally agreed that when an adequate dose of gonadotrophin is injected into the immature female mammal, secretion of œstrogen takes place in the ovary and this in turn causes the uterus to increase in weight. While it is not certain that œstrogen is the only uterine growth-promoting substance liberated by the ovary[1] at that time, this will not alter the interpretation of the findings presented here.

The time-response curve for the increase in uterine weight of immature mice shows a lag phase of up to 18 hr. duration, followed by a phase of logarithmic growth, the uterus reaching a maximum weight about 40 hr. after the injection. The (log dose) – (log response) line is linear over a twenty-fold range of dose, and may be used as a basis for a gonadotrophin assay. It is possible to gain information on the ovarian release of œstrogen by studying the response of the uterus in animals ovariectomized at various times after the administration of œstrogen-free gonadotrophin.

Immature female albino mice weighing about 10 gm. were used in an experiment with pregnant mare serum gonadotrophin, and randomized to boxes, five mice per box. The experimental design employed was a 3 × 4 factorial, one box of animals being allocated to each treatment combination. The factor varied at three levels was dose of gonadotrophin and at four levels the time of ovariectomy. The doses were chosen so that the responses they elicited fell on the linear segment of the (log dose) – (log response) line, and also so that they were equidistant on the logarithmic scale. The dose was administered in one subcutaneous injection of 0·1 ml. isotonic saline. The times of ovariectomy were measured from the time of injection, and chosen so that they were equidistant on the logarithmic time-scale. Thus at 5, 10 and 20 hr. after the injection of gonadotrophin, the animals of one group at each dose-level were

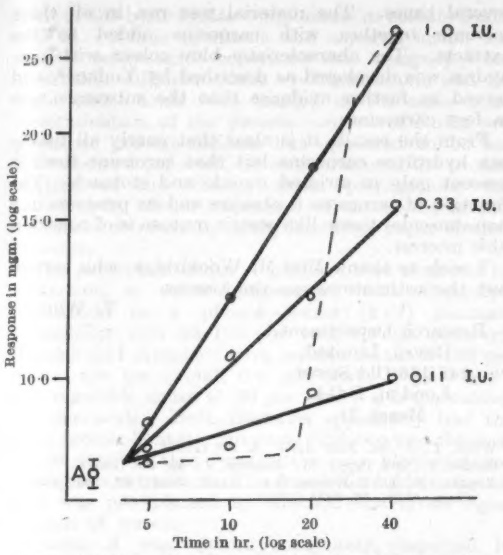

Fig. 1. Effect of various doses of pregnant mare serum gonadotrophin and the time of ovariectomy on the weight of the mouse uterus. ———, the time-response curve for 1 I.U. of the gonadotrophin; Ô, experimental data in the 3 × 4 test. The mean control value (*A*) cannot be placed on the (log scale) since it corresponds with zero time; it has been plotted with a line of ± one standard deviation

ovariectomized under transient ether anæsthesia. All mice were killed and the weight of the uterus recorded 40 hr. after injection, when final groups due for ovariectomy at this time were also killed. Body-weight was recorded at death so that the logarithm of the response may be corrected for the logarithm of this weight by covariance.

After ovariectomy, the uterus continues to grow to a size which is related to the dose of gonadotrophin and the time of ovariectomy. This is shown in Fig. 1, where the ($\log_8$ time) – ($\log_{10}$ response) line is drawn for each dose-level of gonadotrophin. It is apparent that the three lines intersect at a common point, a point also common to the control values obtained from mice ovariectomized at the time of injection (0 hr.), and killed with the others 40 hr. later. These control values were obtained on the same day as the experimental values in order that secular variation in response could be eliminated.

The analysis of variance of the experimental data permits the conclusions listed above and indicates that the data are described by a multiple regression equation of the following form:

$$Y = a + b_1x_1 + b_2x_2 + b_{12}x_1x_2 \qquad (1)$$

where Y is the expected value of ($\log_{10}$ response); b_1 is the regression coefficient relating response to (log dose), x_1; b_2 is the regression coefficient relating response to (log time), x_2; b_{12} is the regression coefficient relating response to the product of (log dose) and (log time); a is a constant.

The abscissa of the point of intersection of the time-response lines is given by the equation:

$$i(x_2) = -b_2/b_{12} \qquad (2)$$

and the variance of this estimate and its 95 per cent fiducial limits may be deduced using Fieller's formula[2]. The ordinate of the point of intersection [$i(y)$] may be obtained by substitution in equation (1).

A second experiment of the same type was carried out, using human chorionic gonadotrophin. These two preliminary experiments indicate that both gonadotrophins cause liberation of œstrogen by the ovary which is effective in the uterus 3·9 {2·6–5·8} hr. after injection. A combined estimate is given since no significant difference was obtained between the gonadotrophins. The ordinates are obviously not different from the control values:

	Pregnant mare serum gonadotrophin	Human chorionic gonadotrophin
Control	87·0 ± 1·46	88·5 ± 1·44
$i(y)$	89·7	85·8

This response has not previously been subject to quantitative study. Astwood[3] showed that the uterus responds rapidly to the subcutaneous injection of œstrogen. Water uptake begins 1–2 hr. after the administration of an effective dose. A maximum response is reached in a further 4 hr. Taking this result together with the estimate given above, it appears that the ovary must begin to liberate œstrogen into the blood stream as early as 2–3 hr. after the administration of gonadotrophin. The three time – response lines are linear over the range in question, and thus the ovary may well continue to produce œstrogen at least for 40 hr. after the initial stimulus; but since no studies have been made in which œstrogen has been withdrawn after early stimulation of the uterus, it is not possible to be certain of this. It is clear, however, that a single injection of either gonadotrophin is effective in causing the release of œstrogen.

While it is somewhat surprising that the two gonadotrophic preparations studied apparently act in a similar manner on the ovary, this is in line with other studies in this laboratory and elsewhere, raising some doubts about the separate identity of the two pituitary hormones, follicle-stimulating hormone and luteinizing hormone. These, however, are not identical with the hormones used by us in the present work, and little can be said without more work on the subject. The quantitative study of secondary responses after organ removal or ablation may prove fruitful in other fields.

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Carnosine and Carnosinase in Rat Tissue

Paper chromatography has been used for obtaining a qualitative picture of the distribution of carnosine and 'carnosinase' in the albino rat.

One-year old animals were killed by chloroform, the tissues removed and ground with acid-washed alumina and 5 ml. of 0·02 *N* potassium cyanide. This amount of cyanide, in control experiments, was found to inhibit completely the moderate 'carnosinase' activity of the uterus, but not the very strong activity of rat kidney.

Table 1

	(1)	(2)	(3)	Colour with diazo reagent
Histidine	0·21	0·07	0·19	red
Carnosine	0·20	0·07	0·36	red
Anserine	0·20	0·07	0·60	none
Histamine	0·24	0·24	0·40	red
Thiolhistidine	0·27	0·15	0·22	yellow
Ergothioneine	0·32	0·24	0·88	yellow
Urocanic acid	0·61	0·67	0·77	red

Solvents: (1) *n*-butanol – glacial acetic acid – water (60 : 15 : 25); (2) *n*-propanol – *N* acetic acid (3 : 1); (3) phenol – hydrochloric acid.

The suspension of ground tissue was centrifuged and the protein in the supernatant precipitated with 10 per cent trichloracetic acid, the excess of which was removed by extracting three times with ether. The clear solutions were taken to dryness *in vacuo* over sulphuric acid and the residues dissolved in 10 per cent *iso*propanol. Chromatograms were run on Whatman No. 4 papers in phenol–hydrochloric acid[1] (200 ml. of 80 per cent phenol equilibrated overnight with a mixture of 120 ml. concentrated hydrochloric acid and 40 ml. of water placed in a separate container at the bottom of the tank). The chromatograms were dried and hung in the air for 4–5 days to remove traces of phenol then developed with diazotized *p*-anisidine[2], a reagent which will detect 0·2 μgm. of carnosine on the paper. A list of R_F values is given in Table 1.

'Carnosinase' activity was measured in tissues from a rat killed by a blow on the head. The tissue was ground with acid-washed alumina and 5 ml. of 0·18 *M* borate buffer *p*H 8·0 and the mixture divided into two portions, one of which was boiled to serve as a control. The tissues and buffer were added to stoppered tubes containing 1 mgm. of carnosine and incubated at 37° C. for 3 hr. After the incubation the mixture was centrifuged and the supernatant deproteinized, etc., as described above.

Hydrolysis of carnosine was revealed by the appearance of a histidine spot not present in the controls. The amounts of material placed on the paper in these enzyme experiments were such that the small amounts of histidine present in the tissues did not show up.

In addition to rat tissues, toad stomach was investigated. A toad was pithed, the stomach removed, washed in Ringer's solution and the mucosa peeled away from the smooth muscle coat. The results are given in Table 2.

Since stomach was the only tissue, apart from striated muscle, in which carnosine was detected, the experiments on rat and toad stomachs were repeated several times. The material was run in all three solvents together with carnosine added to the extracts. The characteristic blue colour with ninhydrin was developed as described by Yudaev[3], and served as further evidence that the substance was in fact carnosine.

Table 2

	Carnosine	Histidine	Carnosinase activity
Rat			
Stomach	++	+	+
Spleen	–	+	+
Kidney	–	+	++
Uterus	–	+	+
Liver	–	++	++
Heart	–	+	++
Diaphragm	+	+	+
Bladder	–	trace	+
Muscle	++	+	trace
Blood serum	–	+	–
Blood cells	–	trace	–
Lung	–	trace	++
Brain	–	trace	++
Small intestine	–	+	++
Toad			
Smooth muscle	trace	–	–
Mucosa	++	–	+

From the results it is clear that nearly all tissues can hydrolyse carnosine but that carnosine itself is present only in striated muscle and stomach. The function of carnosine is obscure and its presence in a non-muscular tissue like gastric mucosa is of considerable interest.

I wish to thank Miss M. Wooldridge, who carried out the estimations on the tissues.

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Application of Ethylenediaminetetra-acetic Acid in the Isolation of Crustacean Chitin

Isolation of 'chitin' {which generally connotes a polysaccharide comprising units of 2-acetamido 2-deoxy-D-glucose (N-acetyl-D-glucosamine)} from the cuticles of crustaceans usually involves[1] decalcification; for example, treatment with *N* hydrochloric acid followed by repeated, prolonged extraction of the insoluble residue with *N* sodium hydroxide at 100°. The material remaining undissolved by this treatment is termed 'chitin'. Such drastic treatment may well effect structural changes in the chitin, such as removal of pendant groups (protein or peptides), de-N-acetylation and fragmentation. Little is known of the mode of association of chitin with protein and a knowledge of this is of importance in studies of the biosynthesis and biological function of chitin.

In seeking milder methods for the isolation of chitin, we have studied the action of ethylenediaminetetra-acetic acid on the cuticle of the edible crab, *Cancer pagurus*. Only those parts of the fresh, cleaned, air-dried cuticles which were free from hairs were used. Large (1 cm.²) cuticle fragments were attacked slowly (50 per cent loss in weight in two weeks) by ethylenediaminetetra-acetic acid at *p*H 9. Powdered shell {particle size 1–10μ; ash (as oxide), 45 per cent; spectrographic analysis: CaO, 77; MgO, 4·5; SiO_2, 5·6; P_2O_5, 8·2 per cent (error ± 10–20 per cent)} was decalcified rapidly (in less than 15 min.) on treatment with excess ethylenediaminetetra-acetic acid at *p*H 9. No carbohydrate material was extracted in this process. After a further treatment with ethylenediaminetetra-acetic acid at *p*H 3, the residue was extracted with ethanol (pigment removal) and ether (lipoid removal). The chitin (*A*) so obtained was an off-white colour {ash (as oxide), 2·6 per cent; spectrographic analysis: SiO_2, 107; MgO, 0·08 per cent (error ± 10–20 per cent)}. Found (corrected for ash in parentheses): C, 42·3 (43·5); H, 6·4 (6·6); N, 7·4 (7·6). Calculated for $(C_8H_{13}O_5N)_n$: C, 47·3; H, 6·4; N, 6·9 per cent. That chitin *A* contained protein was demonstrated by hydrolysis (6 *N* hydrochloric acid for 24 hr.) followed by paper electrophoretic separa-

tion[2] of the hydrolysate components in acetate buffer (*p*H 5). Acidic (glutamic and aspartic acids) and neutral amino-acids separated into compact zones detectable with ninhydrin. D-Glucosamine and the basic amino-acids were located in the same zone. Determination of the protein content of chitin preparations proved difficult but appeared to be less than about 5 per cent. A comparison of the protein content of the various chitin preparations was achieved by visual inspection of the acidic amino-acid zone detected by ninhydrin after paper electrophoresis.

The protein in chitin *A* could not be removed by extraction at room temperature with dimethylformamide or a phenol – water (9 : 1) mixture. Extraction with 98–100 per cent formic acid (cf. Schulze and Kunike[3]) gave soluble chitin *B* {69 per cent; ash (as oxide), 0·8 per cent; $[\alpha]_D$ 0 ± 2°} and insoluble chitin *C* {31 per cent; ash (as oxide), 4·8 per cent}. Both fractions apparently had the same protein content, but some evidence was obtained which suggests that formylation may have occurred during the extraction. The fraction soluble in formic acid was precipitated by the addition of an equal volume of water.

Chitin *A* was almost completely dispersed in aqueous lithium thiocyanate[4] (saturated at room temperature) at 95–100° to give chitin *D* ($[\alpha]_D$ − 24 ± 5°). Progressive dilution of the extract with acetone gave a series of chitin fractions which, expressed as a percentage of original chitin in solution with acetone percentage in parentheses, were *E*, 77 per cent (50); *F*, 11 per cent (75); *G*, 11 per cent (90). The protein content of these fractions was similar. Fractionations of chitin *A* were also achieved using dilute solutions of lithium thiocyanate and/or lower extraction temperatures. The protein content of all these fractions appeared to be similar. In no case was a protein-free chitin fraction obtained.

The protein content of chitin *A* could be substantially reduced but not completely eliminated by repeated extraction with hot alkali (cf. Hackman[1]) to give chitin *H*.

The above observations strongly suggest that the protein in chitin *A* is bound chemically to the mucopolysaccharide. There has been speculation[5] in the literature concerning the existence in the arthropod cuticle of a glycoprotein, and in the case of *Cancer pagurus* this would appear to be so. Also indicated by the above fractionations is the polydisperse nature of chitin *A*. In this connexion it would be of interest to determine the molecular weight of the various fractions described above and, now that solvents for chitin are available, methods such as that devised by Isbell *et al.*[6] theoretically should be applicable. This aspect is being further examined, as is the precise nature of the protein–chitin linkage.

The close general similarity of the infra-red spectra[7] of chitin *A* and the almost protein-free chitin *H* suggests a close structural relationship between them and, further, indicates a protein content of less than 5 per cent in chitin *A*. It should be emphasized that a very small amount of de-N-acetylation and/or fragmentation in converting chitin *A* into chitin *H* would not easily be detected in the infra-red spectra.

Full experimental details of this investigation will be published in due course.

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Two New Bacteriophages for Bacterial Pathogens of the Bean

The bacterial pathogens of beans are widespread all over the world. In most cases four species of bacterium are the main causal organisms: *Pseudomonas phaseolicola* (Burkholder) Dowson, *Xanthomonas phaseoli* (E. F. Smith) Dowson, *Corynebacterium flaccumfaciens* (Hedges) Dowson, and *Xanthomonas phaseoli* var. *fuscans* (Burkholder) Starr et Burkholder. The symptoms, on the seed, of the diseases caused by these four bacteria are similar to such an extent that they can be identified only by means of laboratory methods. Katznelson *et al.*[1] succeeded in isolating the phages for *P. phaseolicola* and *X. phaseoli*. The Canadian authors worked out a rapid phage-count method using these two phages. By means of this procedure they were able to detect the halo-blight organism (*P. phaseolicola*) and the common blight bacterium (*X. phaseoli*) in beans. In order to apply this method for all the four important pathogens of beans, it was necessary to isolate also the phages for *C. flaccumfaciens* and *X. phaseoli* var. *fuscans*. This work, which was undertaken because *C. flaccumfaciens* and *X. phaseoli* var. *fuscans* are the major causative agents of bean diseases in Hungary, was recently carried out in our laboratory.

We have isolated specific phages for both *C. flaccumfaciens* and *X. phaseoli* var. *fuscans* from naturally infected bean seeds. The ground seeds were suspended in nutrient broth and were inoculated with the host cells susceptible to the phages to be tested. After an incubation period of 48 hr. at room temperature, the samples were centrifuged and filtered through Seitz pads. The active filtrate was passed five to seven times until we obtained typical plaques on nutrient broth agar.

The plaques of phage for *C. flaccumfaciens* could be seen after 10–12 hr. at 28° C. On 0·75 per cent agar medium (glucose-broth-agar) the phage forms clear, circular plaques of 1–2 mm. in diameter, with entire margins.

The plaques of the phage for *X. phaseoli* var. *fuscans* appeared after 20–24 hr. They are larger than those of the other phage mentioned above (3–4 mm. in diameter), are clear, round and have entire margins.

Both phages were tested for specificity against a variety of strains of their homologous organisms, as well as of other species. These results are reported in Table 1.

Table 1. Specificity of Phages for *C. flaccumfaciens* and *X. phaseoli* var. *fuscans*

Organisms tested	Phage for	
	C. flaccumfaciens	*X. phaseoli* v. *fuscans*
C. flaccumfaciens (E629)	+	−
(and 24 strains of it)	+	−
P. phaseolicola	−	−
X. phaseoli (from Germany)	−	−
X. phaseoli (from England)	−	−
X. phaseoli var. *fuscans* (E736)	−	+
(and 4 strains of it)	−	+
X. carotae	−	−
X. malvacearum	−	−
X. uredovorus	−	−

It can be seen that the phage for *X. phaseoli* var. *fuscans* is highly specific, since it does not lyse the closely related *X. phaseoli*.

This work shows that if we have the phages for all the four important bacterial pathogens of bean, the method described by Katznelson *et al.* may be applied in its entirety.

Detailed accounts of this work will be published elsewhere.

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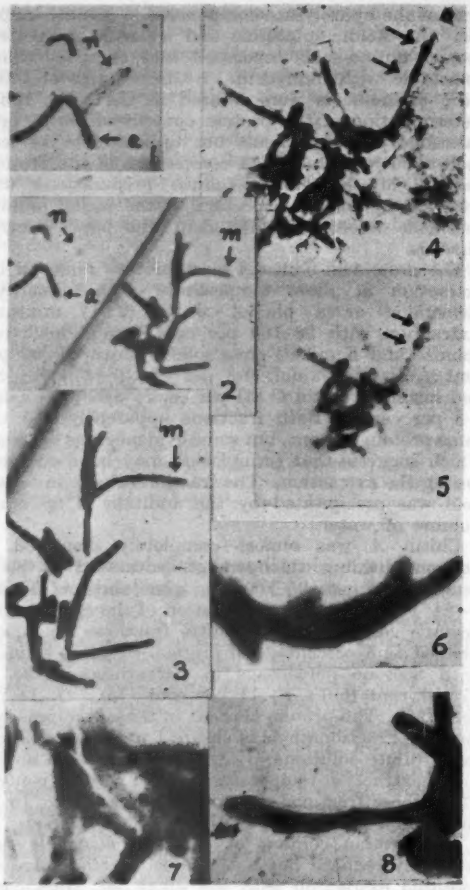
Morphological Changes of Tubercle Bacilli caused by Staining Procedures

We have studied with the electron microscope the morphological changes of tubercle bacilli caused by Ziehl-Neelsen's and Fontes' stainings. *BCG* was stained on the specimen-holders by these methods and photographed with the light microscope, using the volatile anisol immersion-system; the same bacilli were photographed again with the electron microscope. A similar method has been used by Takeya *et al.*[1] and Glauert and Brieger[2] in other staining procedures.

The acid-fast bacilli prove to be narrow shrunken cellular bodies having high electron density and no visible internal structures (Fig. 1, *a*). There is a non-acid-fast form of tubercle bacillus which is a ghost cell consisting of only a cell wall (Fig. 1, *n*), and its electron-scattering power is lowest of all the cells. There is also a small non-acid-fast form of tubercle bacillus which has somewhat higher electron density. The cytoplasm of the moderately acid-fast form of the tubercle bacillus has low electron density and is torn to small pieces (Fig. 3, *m*). According to these findings, the electron density of tubercle bacilli is considered to be related in some way to acid-fastness. In fact, extraction of lipid decreases the electron density and the acid-fastness. The bacilli stained by Fontes' method are found to be slender shrunken cells having oval dense granules, which are larger than the width of the cells and are irregularly bounded (Figs. 4, 5). No electron-dense granules are found in these stained bacilli, although such granules are observed in 73 per cent of the cells before the staining

We have also investigated some possible causes of these changes. Neither the fixative (90 per cent alcohol), dye solvent (alcohol) nor decolorizing agents (3 per cent hydrochloric acid–alcohol or acetone–alcohol (1 : 1) and Lugol's solution) has any conspicuous influence upon the configuration and the electron density of the bacilli in the conditions of usual staining procedures. According to Glauert and Brieger[2], the staining of *Mycobacterium phlei* with Giemsa increases the electron density. A large amount of dye deposited on the bacilli is considered to increase their electron density. The increased electron density of *BCG* stained with 10 per cent alcoholic solution of fuchsin at room temperature for 48 hr. (Figs. 6, 7) is lower than that of *BCG* treated with 5 per cent carbol for 10 min. at room temperature. Moreover, the carbol treatment causes the bacillary cytoplasm to contract and the electron-dense granules to disappear. The configuration and electron density of the bacilli treated with 5 per cent carbol show a close resemblance to those of the bacilli stained by Ziehl-Neelsen's method (Fig. 8). The intensity of the changes is parallel with the degree of heating. In each change the carbol content of these stains may be considered to play a greater part.



(1) Acid-fast (*a*) and non-acid-fast (*n*) *BCG*. × 5,300. (2) Photomicrograph of the same bacilli as in Figs. 1 and 3. × 2,500. (3) Moderately acid-fast *BCG*(*m*). × 5,300. (4) Electron micrograph of the same bacilli as in Fig. 5. × 3,000. (5) Photomicrograph of *BCG* stained by Fontes' method. × 2,700. (6) *BCG*. × 8,400. (7) *BCG* stained with alcohol solution of fuchsin. × 8,100. (8) *BCG* treated with 5 per cent carbol. ×10,700

However, in the increase of the electron density of the bacilli stained by Ziehl-Neelsen's method, other factors, such as the stain and the lipid material, should be taken into consideration.

In short, in the staining procedures of Ziehl-Neelsen's and Fontes' methods, most of the cells of *BCG* contract and their electron density increases though the electron-dense granules disappear. Accordingly, the granules detected in the specimens stained by these methods are different from the electron-dense granules, which are considered to occur naturally. The carbol of the stains which are used is among the causes of these changes.

We thank Profs. Hibi and Kuroya, of Tôhoku University, for their assistance, and Dr. E. M. Brieger, Strangeways Research Laboratory, Cambridge, for his instructive comments.

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Lysis of *Vibrio cholerae* by Thymol

Cultures of *Vibrio cholerae* are very sensitive to thymol. The addition of 50 mgm. of this substance to 10 ml. of 4-hr. broth cultures results in rapid clearing due to massive lysis of the organisms. This takes about 30–45 min. at 37° C., by which time the cultures are sterile. As thymol is soluble in aqueous media only to the extent of 1 in 1,500, the effective concentration required to lyse *V. cholerae* may be of this order. The rapidity with which this occurs simulates the phenomenon of 'induction' observed in certain lysogenic bacteria, when they are exposed to ultra-violet radiation or X-rays or treated with chemical mutagens. However, lysogenic cultures of *V. cholerae* exposed to thymol do not reveal any appreciable increase in free phage particles in the lysates. Further, 'indicator' strains which have proved useful in the detection of lysogenic strains and which appear to be non-lysogenic themselves are lysed equally effectively by thymol.

Other phenols such as catechol, resorcinol, menthol and carbolic acid do not lyse these cultures to a perceptible degree in such a short time. Of these, only carbolic acid is lethal to *V. cholerae*. It is possible that thymol, by virtue of its low toxicity and marked vibriolytic activity, may be useful in clinical and laboratory studies on cholera.

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Fomes lignosus, a Pyrimidine-deficient Fungus

The growth requirements of a number of brown-root and white-root disease fungi have already been studied. It is generally recognized that the majority of the Hymenomycetes are partially or totally deficient in thiamine (aneurin, vitamin B_1)[1].

So far as can be ascertained from the literature available, one of the most important root disease fungi, especially of tropical plants, *Fomes lignosus* (Klot.) Heim ex. Pat., has not so far been investigated in this respect[2]. Attempts to grow *Fomes lignosus* on artificial media, as those of Czapek, Fries, Richard and Knop[3], have been unsuccessful. However, as soon as organic materials such as malt extract, yeast extract or decoctions of fresh rubber wood or of rubber leaves were added, luxuriant growth of the fungus occurred, and, in the culture flasks, the well-known rhizomorphs were formed.

Table 1. pH and Mycelium (Dry Weight in Mgm.) of *Fomes lignosus* on Knop-Glucose Medium With and Without Asparagine, Thiamine, Thiazole and Pyrimidine after 28 Days at 27° C.

Culture medium	pH of culture medium: At beginning	pH of culture medium: At end	Mycelium per flask (dry weight in mgm.)
Knop + 10 gm./l. glucose	5·0	4·8	1·5
Knop + 10 gm./l. glucose + 1 gm./l. asparagine	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 0·5 mgm./l. thiamine	5·0	4·8	1·3
Knop + 10 gm./l. glucose + 0·5 mgm./l. thiazole	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiamine	4·9	4·2	331·5
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. pyrimidine	4·9	4·2	326·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiazole	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiazole + 0·5 mgm./l. pyrimidine	5·0	4·2	323·8
Knop + 10 gm./l. glucose + 1 gm./l. malt extract	4·9	4·1	251·2
Knop + 10 gm./l. glucose + 1 gm./l. yeast extract	4·9	8·3	334·8

The experiments were carried out in 500-ml. 'Jena' Erlenmeyer flasks. Each series consisted of ten flasks, and each flask contained 100 ml. of the liquid culture medium. All experiments were replicated three times. The chemicals used were of the "pro analysis" grade (Merck) or the special "Biochemicals" of Hoffmann–La-Roche.

To obtain a uniform inoculum for these experiments the fungus was grown in advance for 42 days on pieces of fresh rubber wood, and a mycelium suspension was prepared by adding 100 ml. of sterile distilled water and vigorously shaking the culture flasks. Preculturing the fungus on small pieces of wood was advantageous compared with preculturing on a rice or liquid medium. The Erlenmeyer flasks were inoculated by the wet method, each flask with 0·5 ml. of the mycelium suspension, and the cultures were incubated at 27° C. Knop solution containing 10 gm./l. of vitamin-free glucose was used as basic medium for these experiments. The results of the experiments are presented in Table 1.

Fomes lignosus is a fungus which is unable to synthesize the whole thiamine (thiamine hydrochloride, $C_{12}H_{17}ON_4SCl.HCl$) molecule. It can synthesize only one part, thiazole (4-methyl-5-(β-oxyethyl)-thiazole, C_6H_9ONS); the other part, pyrimidine (2-methyl-4-amino-5-aminomethyl-pyrimidine-dihydrochloride, $C_6H_{10}N_4.2HCl$), must be supplied from other sources.

A further interesting fact brought out in these experiments is that the pure Knop solution with 10 gm./l. glucose and thiamine or pyrimidine is not sufficient for satisfactory growth and that in addition asparagine had to be added. How far asparagine can be replaced by other organic nitrogen sources and

how far *Fomes lignosus* can utilize nitrates are questions which are the subject of further studies.

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Effects of Nucleic Acids on Larval Growth, Pupation and Adult Emergence of *Pseudosarcophaga affinis* (Fall.)

The recent report by Brust and Fraenkel[1] that ribonucleic acid inhibits emergence of adults of *Phormia regina* (Mg.) from the pupae prompted an immediate investigation of the effects of this component of the diet of *Pseudosarcophaga affinis* (Fall.) (Diptera: Sarcophagidae).

The experimental methods used and the composition of the chemically defined diet have been described previously[2]. This diet normally contains 0·1 per cent ribonucleic acid, but for this investigation diets were made up that contained 0, 0·025, 0·05, 0·1, 0·2, and 0·4 per cent. Fifty larvæ were reared on each diet, and the experiment was replicated seven times. The ET_{50} (time, measured to nearest day, required for 50 per cent of the larvæ to reach third instar) was determined for each replicate. The percentage of larvæ in third instar in each treatment group on the ET_{50} of the particular replicate was observed and noted.

Whether deoxyribonucleic acid is as satisfactory as ribonucleic acid at the 0·1 per cent level was tested in a second series of experiments. Three media were compounded, one containing 0·1 per cent ribonucleic acid, one containing 0·05 per cent ribonucleic acid + 0·05 per cent deoxyribonucleic acid, and one containing 0·1 per cent deoxyribonucleic acid. One hundred larvæ were reared on each diet, and the experiment was repeated three times.

Each result in Table 1 represents the mean of seven observations. This table shows that growth, pupation, and emergence of adults did occur without ribonucleic acid in the diet and that the addition of ribonucleic acid had little or no effect on pupation. Adding up to 0·1 per cent ribonucleic acid improved larval growth ($P < 0·01$), an effect previously observed with *Drosophila melanogaster* Mg.[3,4], the housefly, *Musca domestica* L.[5], and *P. affinis*[6], but not with *Phormia regina* (Mg.)[1]. However, with more than 0·05 per cent ribonucleic acid in the diet, fewer adults emerged ($P < 0·01$), and the observation of Brust and Fraenkel[1] is confirmed, but only concerning the effect of dietary levels of ribonucleic acid greater than 0·05 per cent.

Table 1. Effects of Ribonucleic Acid on Larval Growth, Pupation and Adult Emergence of *Pseudosarcophaga affinis* (Fall.)

Diet No.	Percentage RNA in diet	Percentage larvæ in third instar at ET_{50} for replicate*	Percentage of larvæ pupating	Percentage of pupæ producing adults†
1	0	6·9	72·5	30·7
2	0·025	42·1	83·4	32·5
3	0·05	59·0	84·6	41·0
4	0·1	70·9	83·1	26·1
5	0·2	71·5	83·3	19·2
6	0·4	69·8	80·0	16·9

* Larval growth on diets 1, 2 and 3 significantly slower than on diets 4, 5 and 6 ($P < 0·01$).
† Adult emergence on diets 4, 5 and 6 significantly less than on diets 1, 2 and 3 ($P < 0·01$).

The second series of experiments indicated that deoxyribonucleic acid was equivalent to ribonucleic acid for this insect (F value < 1) in its effect on larval growth, pupation, and emergence of adults. Thus *P. affinis* differs from *Phormia regina*, in which deoxyribonucleic acid promotes pupation[1], and from *D. melanogaster*, in which it is not equivalent to ribonucleic acid[4] or may even have a deleterious effect on development[3].

As a result of these experiments, 0·075 per cent ribonucleic acid will be used in future diets for *P. affinis* to preserve most of the effect on larval growth and yet avoid much of the effect on emergence of adults. The results also demonstrate the importance of having more than one criterion of the adequacy of diets.

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Water-Relations and Sporulation of *Peronospora tabacina* Adam.

Although it is generally recognized that high humidities favour sporulation of downy mildews, the review of Yarwood[1] indicates the paucity of quantitative data on this aspect of their development. Armstrong and Sumner[2] reported that, under field-conditions, normal sporulation of *Peronospora tabacina* was limited to the range of humidity from atmospheric saturation to slightly below dew point. Laboratory experiments have been carried out at Canberra to study quantitatively the sporulation of *P. tabacina* as a function of the water relations of its host (*Nicotiana tabacum* L. var. Turkish Sampson) under controlled environmental conditions.

Physiologically similar leaves were detached from uniform glasshouse-grown tobacco plants (mean height, 23 cm.), inoculated with a spore suspension and incubated at 100 per cent relative humidity at 21° C. for five days. Leaf disks (15 mm. diameter) were punched from the infected non-sporulating leaves and transferred, ventral surface upwards, to controlled-environment conditions within sealed Petri dishes incubated at constant temperature (21° C.) and alternating light and dark conditions (photoperiod of 12 hr. at 600 lux, fluorescent light) for 24 hr.

The relative humidity of the atmosphere above the leaf disks was controlled by glycerol–water solutions in Petri dishes. The diffusion pressure deficit of the leaf tissue was adjusted by floating the leaf disks on mannitol solutions contained in

Fig. 1. Micro-environment chamber

'Perspex' cells (15 mm. diameter, 5 mm. deep, Fig. 1) standing in the glycerol–water solutions. Leaf disks were randomized after being punched out. Three leaf disks and 'Perspex' cells were placed in each Petri dish. Six leaf-disk replications were used in all experiments.

Sporulation intensity per unit area of infected leaf was measured by dropping each disk into 0·5 ml. of 50 per cent ethanol in 25-ml. McCartney bottles. The latter were shaken for ½ min. on a 'Microid' shaker and the concentration of the spore suspensions measured by counting standard fields in a hæmocytometer chamber. Results were analysed using the log $(x + 1)$ transformation. The transformed means of the spore concentration counts were plotted against relative humidity or diffusion pressure deficit, and hand-fitted curves drawn (Fig. 2).

Results of experiments studying sporulation as a function of relative humidity with diffusion pressure deficit, temperature and light conditions constant, and sporulation as a function of diffusion pressure deficit with relative humidity, temperature and light conditions constant are presented in Fig. 2. In both experiments a significant difference between treatments ($P < 0{\cdot}001$) occurred between 2·6 atmos. and 5·1 atmos. diffusion pressure deficit, and between 96 per cent and 97 per cent relative humidity, respectively. Elsewhere differences in sporulation intensity were not significant.

These preliminary results suggest that not only atmospheric humidity but also the diffusion pressure deficit of the host tissues are of critical importance in the sporulation of *P. tabacina*. Either a relative humidity less than 97 per cent or a diffusion pressure deficit greater than 3–4 atmospheres under otherwise favourable environmental conditions significantly reduces sporulation intensity. In this way the external and internal water relations of the host may affect, directly and indirectly respectively, the epidemiology of downy mildew diseases, for under field conditions a reduction in sporulation intensity per unit area of infected leaf reduces the secondary spread of the disease during the growing season.

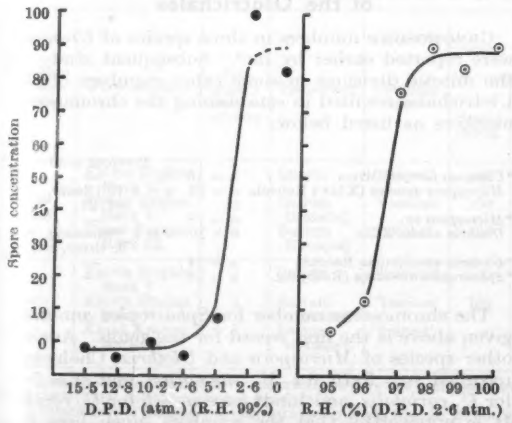

Fig. 2. Relation between diffusion pressure deficit (D.P.D.), relative humidity (R.H.) and sporulation of *P. tabacina*

A full account of this work will be published elsewhere. Thanks are due to Mr. M. L. Dudzinski, Section of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization, who undertook the statistical analyses of the data.

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Mitosis in Vegetative Hyphæ of Higher Fungi (Hymenomycetes)

To find out mitotic stages, vegetative hyphæ of an agaric (wild variety of *Psalliota campestris*) and a polypore (*Polyporus cuticularis*), growing in culture on liquid 3 per cent malt medium, were fixed at intervals of half an hour from 2 p.m. to midnight; it was found by these trials that 8 to 8.15 p.m. (at night) was the most suitable period for demonstration of mitotic stages in these two cases under our laboratory conditions (temperatures of 25°–32° C.). A number of fixatives (such as Allen's Bouin, Carnoy, Navashin and Fleming's strong fluid) and stains (iron-hæmatoxylin, gentian violet, aceto-orcein and Feulgen) were used, of which the Fleming's strong fluid preceded by pretreatment in cold (15°–16° C.) for 1½ hr. with aesculin and 1 per cent saponin, and acet-orcein and Feulgen stains were found to be best. The squash technique of applying uniform pressure on the cover-slip readily brought out scattering and clarity of the small chromosomes which can scarcely be expected from the routine method of paraffin block-sectioning.

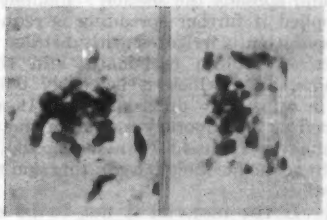

Fig. 1. *Psalliota campestris* (wild var.).
(*a*) Late prophase (× 5,000 approx.).
(*b*) Polar view of metaphase (× 2,000 approx.)

Aesculin is a growth-retarding substance, obtained from *Aesculus hippocastanum*. Probably, pretreatment with aesculin and 1 per cent saponin in the cold helps easy penetration of the fixing fluid through the chitinous and complex walls of the higher fungi. The number of chromosomes of the somatic nuclei in *P. campestris* (Fig. 1*a* and *b*) seems to be higher ($n = 9$). Colson[1], when studying meiosis in basidia of *P. campestris*, recorded the

haploid number of chromosomes for both wild and cultivated forms of *P. campestris* as nine gemini.

Details of the work will be published elsewhere.

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An Acetocarmine Squash Technique for the Fucales

Acetocarmine techniques have only been used to a limited extent in cytological studies of the Phaeophyta, and only in examination of filamentous forms, or filamentous phases in the life-history of the larger forms. Investigations of the Fucales have relied on techniques of embedding and microtoming, followed by staining with Heidenhain's hæmatoxylin[1] or crystal violet[2].

The chief obstacles to the use of acetocarmine squash techniques in the Fucales are the pigmentation, which may obscure or block the staining, and the nature of the cell wall, which is insufficiently macerated by the acetic acid to allow the necessary degree of squashing. Both these difficulties can be overcome by pretreatment with hydrogen peroxide and sodium carbonate according to the following schedule.

Fixation. Small portions of the material, either apices or receptacles, are fixed for 24 hr. in Karpechenko fixative[3] and then washed thoroughly in water.

Bleaching. Bleaching is carried out immediately after fixation: in all the species examined, 4 hr. in 20 per cent hydrogen peroxide produces a suitable degree of bleaching and also causes a preliminary softening of the cell walls, which helps in the subsequent spreading of the squash. After bleaching, the material is thoroughly washed and then treated with acetocarmine.

Acetocarmine treatment. Hand-sections of the region to be examined are mounted on a filmed slide in a drop of 6 per cent sodium carbonate. This converts any alginate into sodium alginate, and as the preparation is gently warmed, the weight of the coverslip squashes and spreads the section: manual pressure can be applied if further spreading is required.

The preparation is irrigated with distilled water to remove excess sodium carbonate, and then with acetocarmine, after which it is gently boiled until the stain is sufficiently differentiated. It may then be examined as a temporary mount in the acetocarmine, or made permanent by allowing the coverslip to fall off in acetic alcohol, dehydrating and mounting in 'Euparal'.

Storage. If the material is not to be examined immediately after bleaching, it may be stored in acetic alcohol made up of one part of glacial acetic acid to three parts of absolute alcohol, with ferric acetate dissolved in 45 per cent acetic acid added until it is a light amber colour. After rinsing in alcohol to remove excess acetate, acetocarmine squashes can be made as above.

Using this technique, growing apices and developing receptacles of several species of *Fucus* and *Cystoseira*, *Himanthalia elongata* and *Halidrys siliquosa* have been examined, and many stages of division found. Fig. 1*a* shows a metaphase plate in a vegetative cell in the apical groove of *Himanthalia elongata* obtained

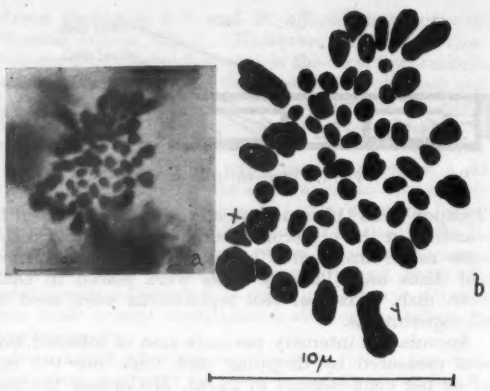

Fig. 1. (*a*) Photomicrograph of a metaphase plate from a cell in the apical groove of *Himanthalia elongata*. (*b*) Analysis of plate shown in (*a*). At *x* one chromosome is at a higher focal level; at *y* the chromosome is scarcely in the focal plane of (*a*)

by this method, and Fig. 1*b* an analysis of this plate made by enlarging the negative to a greater degree, inking in the chromosomes and bleaching the print. This is then checked visually against the preparation. Fig. 1 gives a count of 60 chromosomes. A number of metaphases have been examined in this way and give counts ranging between 56 and 62—a variation possibly due to the fact that many of the chromosomes show separation into chromatids and it is not always possible to distinguish them.

Thus, by using this technique on actively growing apices and developing conceptacles, nuclear divisions in the Fucales may be obtained with little more trouble involved than in making root-tip squashes or pollen grain smears.

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Chromosome Numbers in Some Members of the Ulotrichales

Chromosome numbers in three species of *Uronema* were reported earlier by me[1]. Subsequent study of the mitotic divisions in some other members of the Ulotrichales resulted in establishing the chromosome numbers as listed below.

		Previous counts
**Uronema terrestre* Mitra	$n = 16$	—
Microspora amoena (Kütz.) Rabenh.	$n = 32$	$n = 8$–12 (Neuenstein, ref. 2)
**Microspora* sp.	$n = 18$	—
Ulothrix zonata Kütz.	$n = 10$	$n = 4$ (Schussnig, ref. 3, Gross, ref. 4)
**Ulothrix subtilissima* Rabenh.	$n = 14$	—
**Sphaeroplea annulina* (Roth) Ag.	$n = 16$	—

The chromosome number for *Sphaeroplea annulina* given above is the first record for the genus. Among other species of *Microspora* and *Ulothrix*, Cholnoky[5] recorded $n = 8$–10 for *M. stagnorum* and $n = 7$–8 for *U. variabilis*, and Lind[6] gave $n = 5$ for *U. rorida*. It is noteworthy that the numbers given here for *M. amoena* and *U. zonata* do not confirm the earlier

findings. The extremely small size of the chromosomes in most members of the Ulotrichales is probably the reason for the lack of any extensive cytological work on the group.

The materials indicated by an asterisk in the above list were obtained from the Cambridge Culture Collection of Algae and Protozoa. The materials of *M. amoena* and *U. zonata* were collected from Wise Een Tarn and Lake Windermere respectively. Detailed accounts of mitosis in the above forms will be published elsewhere.

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A Non-Destructive Method of detecting Diseases in Wood

Ultrasonic equipment has been used by the Timber Development Association for detecting flaws in wood, and its possible development for determining the presence of diseased tissues has been suggested[1]. The principle of this type of flaw detection is to generate pressure (sound) waves of very high frequency which are transmitted through suspect materials such as metals or plastics. When flaws are present, the reduction of the degree of transmission in the defective area can be measured. Ultrasonic waves produced by commercial flaw detectors do not harm the materials being tested. The equipment is portable.

In these trials transmission of ultrasonic energy through wood was measured both down and across the grain. After two areas, on exactly opposite sides of the samples, had been smoothed to give two flat surfaces, each about 25 sq. cm. in area, the wood was smeared with a coupling agent to ensure good contact between the probes and the wood. To transmit across the grain the sampling areas had to be stripped of bark, which was found to be impenetrable to the ultrasonic energies employed.

The transmission of ultrasonic energy through wood is considerably reduced even when slight defects are present (Table 1). The sensitivity could probably be increased with sets specially adapted for detecting flaws in timber. No transmission could be obtained through 5 cm. of red pine infected with dry rot even though ultrasonic energy could be transmitted through 130 cm. of sound seasoned beech.

Besides its potential value as a research tool for studying the ecology of tree disease organisms, the most important development of this technique would be the reduction of economic losses of timber. Trees of value are often lost because fungal infections (such as heart and butt rots) remain undetected for many years. The early detection of disease in a plantation would enable a decision to be made about its potential value and future management. Loss on imports or timber in storage could be reduced if a speedy method of detecting incipient decay in bulk timber were available.

We should like to express our thanks to the Atomic Energy Research Establishment, Harwell, and to Messrs. Kelvin Hughes for permission to use equipment at their laboratories; to Mr. E. Skippen, of A.E.R.E., for his advice and assistance; and to Mr. Abel Ward for allowing us to take samples from Eggerslack, Grange-over-Sands.

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Table 1. Relative Transmission of Ultrasonic Energy through Samples of Wood

Direction of transmission	Flaw detector	Frequency (megacycles)	Transducer	Coupling agent	Percentage transmission through sound wood*					
					Birch†			Oak†		
					Sound wood	Wood infected by *Polyporus betulinus*		Sound wood	Sound wood with hole ¼ in. diameter drilled longitudinally	Brittle wood with pockets of rot
						Central rot 32 per cent by vol.	Completely rotten			
Across grain	Kelvin Hughes Mark V	¼	Quartz	'Polycel'	100	0	0	—	—	—
	Kelvin Hughes Mark V	¼	Barium titanate‡	'Vaseline'	100	20	0	100	10	50
	Kraut Kramer Mark IX	¼	Barium titanate‡	'Polycel'	100	17–33	0	100	3–23	12–27
Down grain	Kelvin Hughes Mark V	¼	Quartz	'Polycel'	100	38	0	—	—	—
	Kelvin Hughes Mark V	¼	Barium titanate‡	'Vaseline'	100	10	0	100	—	15
	Kraut Kramer Mark IX	¼	Barium titanate‡	'Polycel'	—	—	—	100	—	55

* Absolute values are not shown as machines were not calibrated and scale values recorded were peculiar to each machine, so values obtained by the individual machines are not comparable.
† Dimensions of samples were approximately 9 cm. wide by 20 cm. long. Samples were obtained from standing trees five days before testing and were preserved by smearing 'Vaseline' on all cut surfaces, then sealed into polythene bags.
‡ Machine not tuned, so efficiency was about 5 per cent.

Eels in Southern Africa

Sponsored by the South African Council for Industrial and Scientific Research, this Department, under the direction of Prof. J. L. B. Smith, is undertaking the study of the life-history of the freshwater eels of the western Indian Ocean. Most authorities have hitherto held that only one species of freshwater eel, namely, *Anguilla mossambica* Peters, occurs in South Africa. Ege[1] recorded a specimen of *Anguilla*

marmorata Quoy and Gaimard, from the Buffalo River, Eastern Cape (27° 30′ E., 32° 57′ S.), but as this was the only one from the continent of Africa its validity has been queried. However, among the eels in this Department and of the Kaffrarian Museum, Kingwilliamstown, we have found six, all females, with pleated gonads full of ova, which are unquestionably *Anguilla marmorata* Quoy and Gaimard. Three of these, 85–135 cm. in length, are from the Keiskama River (27° 13′ E., 33° 03′ S.) (near the Buffalo), and the remainder, 73–108 cm. in length, from the confluence of the Sabi and Lundi Rivers in Southern Rhodesia (32° 25′ E., 21° 10′ S.). In both cases the habitats are mature rivers below the 1,000-ft. contour.

At night, during February and March 1957, upstream migrations of thousands of young eels, at all sizes from 10 to 22 cm., were observed in the Buffalo (27° 30′ E., 32° 57′ S.) and the Kariega Rivers (26° 30′ E., 33° 23′ S.). In samplings taken at this time from the Laing Dam wall on the Buffalo River (27° 30′ E., 32° 57′ S.) three species are present, about 85 per cent being *Anguilla mossambica* Peters. Two specimens, 21·5 and 14·5 cm. in length, are *Anguilla bicolor bicolor* McClelland and the remainder *Anguilla marmorata*. Those from the Kariega River were all *Anguilla mossambica*. A fourth species, *Anguilla nebulosa labiata* Peters, the biology of which has been studied and described in much detail by Dr. Winifred Frost[3], has not yet been found in these southerly rivers.

It is unfortunate that the discovery of *Anguilla marmorata*, in the rivers mentioned above, was made too late to be included in the interesting communication by Dr. W. E. Frost in *Nature* of March 16[3].

R. A. Jubb

Department of Ichthyology,
Rhodes University,
Grahamstown.
April 12.

[1] Revision of the Genus *Anguilla* Shaw, *Dana* Report No. 16, 87 (1939).
[2] Frost, W. E., Col. Off. Fish. Pub. No. 6, 1 (1955); *J. Cape Piscatorial Soc.*, No. 38 (1957).
[3] Frost, W. E., *Nature*, **179**, 594 (1957).

Dirt Removal from Cotton

In the course of investigations into detergency using radioactive isotopes, some interesting observations have been made. The chopped fibre technique[1] was used, and the cotton fibre was soiled as described previously[2], but with a proportion of the stearic acid replaced by stearic acid-1-^{14}C. The rate of removal of stearic acid from the fibre after washing with different detergent solutions for various times was measured by the residual activity of the fibre compared with the initial activity of the unwashed fibre. The fibre was made into smooth pads and activities were determined by an end-window counter.

It was found that the relative efficiencies of the detergents as estimated by the removal of the stearic acid and by that of the pigment (graphite) component of the soiling mixture determined by reflectance measurements showed marked similarities, as illustrated in Fig. 1. In addition, although excess of a strong alkali, sodium metasilicate, was present in all detergent solutions, the removal of the stearic acid depended partly upon the detergent used.

This work is being continued employing different fibres and with each type of fatty component of the soiling mixture labelled in turn with carbon-14.

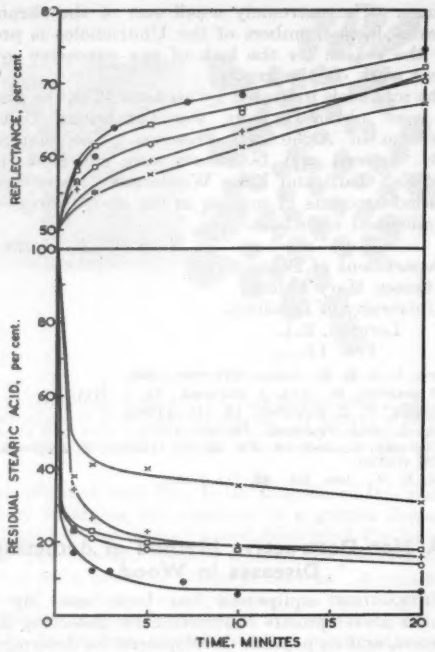

Fig. 1. Removal of radioactive stearic acid and of graphite from cotton. ●+○□, 0·1 per cent of detergents plus 0·15 per cent of sodium metasilicate; ×, 0·15 per cent of sodium metasilicate only

We thank Miss J. C. Gracie for technical assistance, the Isotope Division of the Atomic Energy Research Establishment, Harwell, for helpful advice, and the Director and Council of the British Launderers' Research Association for permission to submit this communication for publication.

R. E. Wagg
C. J. Britt

British Launderers' Research Association,
Hill View Gardens,
Hendon, London, N.W.4.

[1] Powney, J., and Feuell, A. J., *Research*, **2**, 331 (1949).
[2] Wagg, R. E., *J. Textile Inst.*, **43**, *T*515 (1952).

Organo-Clay Complexes

It has been shown by X-ray analysis that certain organic compounds are taken up between the basal surfaces of montmorillonite and halloysite to form interlamellar complexes. The space occupied by the organic molecules is determined by subtracting the van der Waals thickness of individual clay sheets from the observed (001) spacing, and is normally less than that calculated by assuming that the molecules lie as flat as possible and also make van der Waals contact with the surface atoms of the clay. The apparent reduction in thickness has been ascribed to CH . . . O bonds[1–3] between the oxygen atoms of the clay surface, which have an induced negative charge arising from the isomorphous replacement charge, and the organic molecules. Polyvinyl alcohol, the crysta structure of which has been determined, appears to form a two-layer complex with montmorillonite in which there is van der Waals contact between the —CH_2 groups and the surface oxygen atoms, and the plane of the carbon chains is perpendicular to the (001)

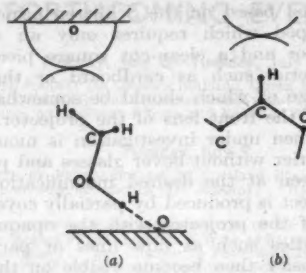

Fig. 1. (*a*) Methanol on montmorillonite; (*b*) higher alcohols on montmorillonite

planes (unpublished work). This suggested that the orientation of the simple alcohols might be such that the plane of the carbon chain is perpendicular to the (001) plane, and not parallel as originally assumed[1,2,4]. The most recent evidence is also against the latter assumption[5].

To account for the observed thickness of the intercalated molecules on this hypothesis, some shortening of the van der Waals contact between the organic molecule and the clay surface is still necessary. It seemed unlikely, both from the result with polyvinyl alcohol and on general chemical grounds, that CH . . . O bonds could be formed; OH . . . O bonds would be more likely, as alcohols are known to form intermolecular bonds in this way in the liquid state.

If an oxygen atom is to form a hydrogen bond with another oxygen atom on the clay surface, two conditions have to be satisfied. The OH . . . O bond must be linear and, more specifically, if the clay oxygen atom is already linked by two bonds at the tetrahedral angle to other atoms in the clay, then the hydrogen bonds would be expected to form at the remaining tetrahedral angles, as in the ice structure, for example. This latter condition is met exactly on both surfaces of montmorillonite crystals, where each oxygen atom is linked by tetrahedral bonds to two silicon atoms, and similarly on one surface of halloysite crystals also. On the other surface of halloysite crystals, each hydroxyl is linked to two aluminium atoms by bonds at 90°, so that conditions are not favourable for hydrogen bonding.

Fig. 1*a* shows the proposed orientation of the methanol montmorillonite complex with the OH . . . O bond at the tetrahedral angle to the clay oxygen atom on one of the clay surfaces. On the other clay oxygen surface van der Waals contact is assumed with the methyl group, with allowance for free rotation of the group. This will give the maximum observable (001) spacing, namely,

OHO cos 54·73 + CO cos 15·79 + CH cos 54·73
+ van der Waals radius H + van der Waals radius O
+ thickness of silicate sheet (from one plane oxygens to another)
= 2·6 cos 54·73 + 1·43 cos 15·79 + 1·07 cos 54·73 + 1·2 + 1·4 + 6·6 = 12·7 A.

The values of the bond-lengths and van der Waals radii are those given by Pauling[6]. The length of the OH . . . O bond is uncertain within 0·1 A.

For halloysite an identical arrangement is possible with the —CH_3 group making van der Waals contact with the hydroxyl layer. The (001) spacing expected would then be:

12·7 − 6·6 + 4·4 = 10·5 A.

The increase in spacing to be expected with the higher alcohols in montmorillonite will be (Fig. 1*b*):

(CC − CH) cos 54·73 + CH cos 54·73
= 1·54 cos 54·73 = 0·89 A., that is, a total (001) spacing of 13·6 A.

For the corresponding amines, methylamine, etc., NH . . . O bonds would be substituted for OH . . . O bonds.

There is some variation among the observed spacings. Glaeser's[7] value of 12·1 A. for the one-layer methanol montmorillonite complex appears to be low, due to incomplete absorption; MacEwan[2] found 10·6 A. for the corresponding methanol halloysite complex, and other workers[1,5] 12·7 A. for the methylamine montmorillonite complex. Glaeser's value for 1-propanol to 1-pentanol on montmorillonite is 13·6 A., the same as MacEwan's value for 1-hexanol, 1-heptanol and secondary alcohols. The corresponding amine complexes give[1,5] spacings of 13·5 A. The general agreement with the calculated values is encouraging.

W. W. Emerson

Rothamsted Experimental Station,
Harpenden, Herts. March 28.

[1] Bradley, W. F., *J. Amer. Chem. Soc.*, **67**, 975 (1945).
[2] MacEwan, D. M. C., *Trans. Farad. Soc.*, **44**, 349 (1948).
[3] Talibudeen, O., *Trans. Farad. Soc.*, **51**, 412 (1955).
[4] Jordan, J. W., *Min. Mag.*, **28**, 598 (1949).
[5] Greene-Kelly, R., *Trans. Farad. Soc.*, **52**, 1281 (1956).
[6] Pauling, L., "The Nature of the Chemical Bond" (Cornell Univ. Press, Ithaca, N.Y., 1940).
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Evidence relating to the Earth's Inner Core from Hydrogen Bomb Explosions in 1954

In an analysis[1] of seismological readings of four hydrogen bomb explosions carried out by the United States in 1954, we discerned a pattern from which we have surmised the origin-times to an accuracy which we think is of the order of 0·2 sec.

Assuming our surmise to be correct, it emerges that stations in the range $137° < \Delta < 142°$, where Δ denotes the epicentral distance, have recorded wave movements from the bombs at times up to 12 sec. before the expected arrival-times. Furthermore, the early movements were found to be followed usually by a second larger phase the times of which agreed within 2 sec. with the expected arrival-times of the phase *PKIKP*. The obvious interpretation of the early readings is that they correspond to diffracted waves arriving at distances short of the *PKP* travel-time cusp at 142°.

A search for diffracted *PKP* waves from natural earthquakes was also made. But while it is likely that there are a number of authentic observations of these waves, epicentral and origin-time uncertainties make it impossible to approach the precision of the inference derived using the hydrogen bomb data. Special significance is attached to the latter, since bomb explosions can permit the precise calculation of travel-times.

The results, which will be presented in detail elsewhere, have an important bearing on the evidence for the existence of the Earth's inner core. Prior to Lehmann's work[2] in 1936, the travel-time branch curve now known as *PKIKP* had been attributed to diffraction effects. It is innate in the calculation of Jeffreys[3] which showed that the readings relating to *PKIKP* could not be attributed to diffraction,

that genuine diffracted *PKP* waves should nevertheless be observable. The present investigation gives evidence of the existence of these diffracted *PKP* waves, and at times up to 12 sec. before the *PKIKP* waves arrive. Thus supplementary proof is given of the fact that the phase *PKIKP* is unconnected with diffraction, and therefore connected with the presence of an inner core.

The present communication incidentally illustrates the potential value of nuclear explosions to seismological research.

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Department of Applied Mathematics,
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T. N. Burke-Gaffney
Riverview College Observatory,
New South Wales.

May 30.

[1] *Austral. J. Phys.*, **10**, 130 (1957).
[2] Bureau Centr. Séism. Internat., A, Fasc. **14**, 3 (1936).
[3] *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **4**, 552 (1939).

Detection of Inhomogeneities in Transparent Plastic Sheet by a Simple Schlieren Technique

Transparent plastic sheet and film of most types of polymer respond well to the Schlieren technique, and this method can be used to obtain magnified images of inhomogeneities in the material which are normally not detectable by visual inspection. A very simple method based on the Schlieren principle has been developed which requires only an ordinary slide projector and a clean-cut square piece of an opaque material such as cardboard or thin sheet metal the size of which should be somewhat larger than that of the front lens of the projector.

The specimen under investigation is mounted on the slide carrier without cover glasses and projected on to a screen at the desired magnification. The Schlieren effect is produced by partially covering the front lens of the projector with the opaque sheet. Inhomogeneities such as flow lines or particles of different density then become visible on the screen in the form of high-contrast magnified images.

The opaque sheet should be held as close as possible to the front lens. Where the front lens is recessed or hooded, it is advisable to remove the projecting rim. In some cases it will be found advantageous to stop down the light by placing an aperture in front of the condenser lens. The position of the sheet with respect to both the degree of lens coverage and the angular direction of the traversing edge at which maximum contrast is obtained depends on the physical and optical properties of the specimen as well as on the type of projector used, and is best found by trial. For plastic sheet and film, which are usually anisotropic, the optimum position of the edge is at right-angles to the direction of orientation of the specimen.

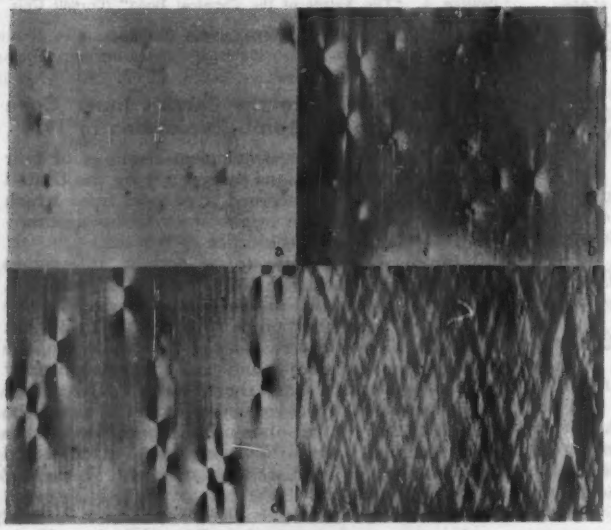

Fig. 1

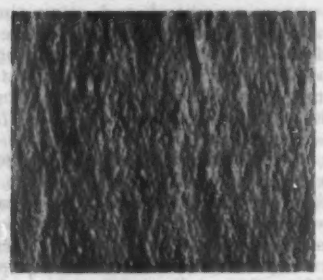

Fig. 2

The effect of this method is shown in the accompanying photographs, which have been taken by placing a photographic plate (Kodak *B* 4) in the position of the screen. In Fig. 1, (*a*) is the image of a cellulose acetate film which was extruded from a non-homogeneous melt, as it appears on the screen on 'straight' projection; (*b*) shows the appearance of the same area of film with the opaque sheet in position; (*c*) and (*d*) are Schlieren pictures of disturbances in similar cellulosic materials due to incorrect manufacturing conditions. The diamond pattern of the flow lines in (*d*) indicates 'cold flow' due to low production temperature. Fig. 2 is a typical image of polythene film. All reproductions are × 20.

In all cases, the pattern revealed by the Schlieren method was not, or only faintly, recognizable on inspection in transmitted or reflected light. A study of the various patterns can supply useful information about the manufacturing history as well as some rheological properties of the plastic, and has been used for identifying different materials.

Alternatively, the opaque sheet may be replaced by a sheet of 'Polaroid', and another sheet of 'Polaroid', which is 'crossed' with respect to the front sheet, placed between condenser lens and specimen. The effect is the same as that of the single opaque sheet; but this arrangement shows in addition whether any of the inhomogeneities are caused by depolarizing substances such as certain organic fibres, which would appear bright.

Thanks are due to the Directors of British Celanese, Ltd., for permission to publish this communication.

H. H. Allen
Physics Development Section,
British Celanese, Ltd., Celanese House,
Hanover Square, London, W.1. March 27.

FORTHCOMING EVENTS

Monday, July 8—Tuesday, July 9

CHEMICAL SOCIETY (in Queen's Building, Queen Mary College, Mile End Road, London, E.1) at 2 p.m. on Monday and 10 a.m. on Tuesday —Symposium on "Solvent Effects and Reaction Mechanism".

Tuesday, July 9

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 4.30 p.m.—Dr. Frederick D. Rossini: "Hydrocarbons from Petroleum".

CIBA FOUNDATION (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N.W.1), at 5 p.m.—Dr. Nathan W. Shock (Baltimore): "Age Changes in Physiological Functions in the Total Animal". (First (Annual) Ciba Foundation Lecture on "Research on Ageing".)

Friday, July 12

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. E. F. Hart: "Methods of Effective Reading".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER or ASSISTANT IN PSYCHOLOGY—The Secretary of University Court, The University, Glasgow (July 12).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Liverpool (July 13).

ASSISTANT LECTURER or LECTURER (with special interests in physical chemistry) IN CHEMISTRY—The Registrar, The University, Sheffield (July 13).

RESEARCH FELLOW IN THE COMPUTING MACHINE LABORATORY—The Registrar, The University, Manchester 13 (July 13).

RESEARCH FELLOW (with postgraduate experience in physiology or allied subjects) IN PHYSIOLOGY, to join work on the physiology of autonomic neuro-effectors—The Secretary, The University, Aberdeen (July 13).

UNIVERSITY LECTURER IN PHILOSOPHY OF SCIENCE—Mr. J. D. Irwin, The Old Schools, The University, Cambridge (July 13).

HEAD (with good qualifications, administrative ability and the capacity to further the development of courses in the application of mathematics to industrial problems) OF THE DEPARTMENT OF MATHEMATICS, including INDUSTRIAL STATISTICS—The Registrar, College of Technology and Commerce, Leicester (July 14).

LECTURER IN EDUCATION—The Principal, Borough Road College, Isleworth, Middlesex (July 15).

PRINCIPAL (with high academic qualifications and considerable experience both in industry and in technical education) OF THE CITY COLLEGE OF TECHNOLOGY, Liverpool—The Director of Education, 15 Sir Thomas Street, Liverpool 1 (July 15).

SENIOR LECTURER IN ORGANIC CHEMISTRY; a SENIOR LECTURER IN MATHEMATICS; a SENIOR LECTURER IN ELECTRICAL ENGINEERING (preferably heavy current); and a SENIOR LECTURER IN BUILDING AND CIVIL ENGINEERING—The Registrar, College of Technology, Suffolk Street, Birmingham (July 17).

SCIENTIFIC COMPUTERS (with an interest in mathematics) to use the latest types of machinery for data processing and statistical calculation—The Group Recruitment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 828/34 (July 18).

ASSISTANT LECTURER or LECTURER IN CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (July 19).

ASSISTANT FORESTRY OFFICER (with a university degree or diploma in forestry and wide experience in all matters relating to forestry)—The County Land Agent, The Old House, Walton Street, Aylesbury (July 20).

LECTURER (preferably with previous experience of university lecturing in general experimental psychology) IN THE DEPARTMENT OF PSYCHOLOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 20).

RESEARCH FELLOW (graduate of any British university) IN BIOCHEMISTRY OR MICROBIOLOGY—The Registrar, The University, Sheffield (July 20).

SENIOR ASSISTANT ENGINEER (with a university degree and/or member of a senior engineering institution, and experience of design and manufacture of boiler plant) IN THE NUCLEAR POWER SUB-DEPARTMENT, Central Electricity Authority, for duties mainly concerned with the design of reactor pressure vessels, boilers and gas ducting for current nuclear power stations—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. T/283 (July 20).

ASSISTANT LIBRARIAN (graduate with some library experience)—The Secretary and Registrar, The University, Highfield, Southampton (July 22).

RESEARCH ASSISTANT (graduate mathematician) IN THE COMPUTING LABORATORY—The Head of the Mathematics Department, Northampton College of Advanced Technology, St. John Street, London, E.C.1 (July 22).

SENIOR SCIENTIFIC OFFICER (honours graduate in aeronautical engineering or science (physics and mathematics) or equivalent qualifications) IN THE AERODYNAMIC DIVISION, Weapons Research Establishment, Department of Supply, Salisbury, South Australia, to initiate and participate in research on aerodynamic and aerothermodynamic problems associated with supersonic and hypersonic missiles—The Senior Representative (A.P.78), Department of Supply, Australia House, Strand, London, W.C.2 (July 22).

UNIVERSITY ASSISTANT LECTURER (preferably specialized in statistics) IN MATHEMATICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (July 24).

SENIOR LECTURER/LECTURER IN (*a*) SOIL MECHANICS AND GEOLOGY; and (*b*) METALLURGY AND STRENGTH OF MATERIALS at Kumasi College of Technology—The Advisory Committee on Colonial Colleges, 1 Woburn Square, London, W.C.1 (July 25).

LECTURER IN APPLIED MATHEMATICS at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

SENIOR LECTURER IN PHYSICS at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 31).

SENIOR LECTURER (able to teach electrical machine theory, power circuit theory and give laboratory instruction in the electrical machine theory); and a LECTURER (able to teach general telecommunications and network theory, and electromagnetic theory) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 12).

LECTURER (with a degree in engineering and preferably with experience or interest in some aspects of heavy power electrical design) IN ELECTRICAL ENGINEERING at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 14).

LIBRARIAN (graduate of a recognized university and with professional membership of an approved library association, or equivalent qualification) OF THE FISHER LIBRARY, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 14).

LECTURER IN AGRICULTURE (PEDOLOGY AND SOIL SCIENCE); a LECTURER IN AGRICULTURE (ANIMAL NUTRITION); a LECTURER IN AGRICULTURAL CHEMISTRY; and a LECTURER IN AGRICULTURAL ZOOLOGY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

LECTURERS (2) (interested in mycology and cytogenetics) IN BOTANY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

READER (or SENIOR LECTURER) and a SENIOR LECTURER (qualified in mathematical statistics and, for the more senior position, widely experienced in the application of statistics to practical and managerial problems) IN STATISTICS at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

SESSIONAL INSTRUCTORS IN CHEMISTRY—The Chairman, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada (August 31).

DIRECTOR (medically qualified and well acquainted with the field of cancer research) OF RESEARCH, Imperial Cancer Research Fund—The Secretary, Imperial Cancer Research Fund, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (November 1).

ASSISTANT LECTURER (physics graduate, preferably with previous experience of teaching), to assist with the development of the new four-year sandwich course in food technology which begins in October —The Principal, National College of Food Technology, Cranwood Street, City Road, London, E.C.1.

DEMONSTRATOR IN ZOOLOGY—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne.

ELECTRONIC ENGINEERS and PHYSICISTS (with, or obtaining, a first- or second-class honours degree or equivalent with experience or interest in radio, radar and communications; instrumentation for telemetry and other measurements; electronic devices; application of advanced techniques to other fields, for example, armament) at Ministry of Supply Research and Development Establishments chiefly at Malvern, Worcs; Farnborough, Hants; and Sevenoaks, Kent—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.514/6A.

GRADUATE IN BIOLOGICAL SCIENCE, to assist in research on mass culture of marine algae—The Professor of Zoology, The University, Southampton.

HEAD (with high academic qualifications and proven farming ability) OF THE DEPARTMENT OF AGRICULTURE, AND FARMS MANAGER, Essex Institute of Agriculture—The Chief Education Officer, County Offices, Chelmsford.

JUNIOR LECTURER (Ph.D. standard in chemistry or biochemistry, and interested in pursuing research in microbiological chemistry) IN THE DEPARTMENT OF BIOCHEMISTRY—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

LABORATORY TECHNICIANS (with a sound knowledge of chemistry and preferably experience of routine biochemical techniques) FOR RESEARCH UNITS—The Administrative Officer, Department of Biochemistry, The University, South Parks Road, Oxford.

LECTURER (preferably with a first-class honours degree in chemical or mechanical engineering, and a taste for personal tuition of students and the initiating and direction of postgraduate research) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—Prof. P. V. Danckwerts, Chemical Engineering Department, Imperial College, London, S.W.7.

ORGANIZING TUTOR/LECTURER (with a good honours degree) IN ZOOLOGY and/or BOTANY—The Director of Extra-Mural Studies, King's College, Joseph Cowen House, 153 Barrass Bridge, Newcastle-upon-Tyne 1.

PHARMACIST at the Westmorland County Hospital, Kendal—The Group Secretary, Royal Lancaster Infirmary, Lancaster.

RESEARCH ASSISTANT (with an appropriate degree or expecting to graduate this year) IN THE DEPARTMENT OF PHYSICAL METALLURGY, to work in the field of the physical metallurgy of steel—The Professor of Physical Metallurgy, The University, Birmingham 15.

SENIOR EXPERIMENTAL OFFICER (preferably with a general scientific degree, or at least H.S.C. (science) or equivalent) to assist in the planning and execution of atomic weapon trials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1524/34.

SENIOR LABORATORY TECHNICIAN (male, preferably between 24 and 30 years of age) IN THE DEPARTMENT OF CHEMISTRY—The Chief Technician, Chelsea Polytechnic, Manresa Road, London, S.W.3.

SENIOR LECTURER (with a good honours degree and industrial experience in electrical supply or power engineering, and preferably teaching experience) IN ELECTRICAL ENGINEERING—The Principal, North Bedfordshire College of Further Education, Holme Street, Bedford.

STATISTICIAN (British graduate) IN THE DIVISION OF BIOMETRY, Institut National pour l'Étude Agronomique du Congo Belge, Yangambi, district of Stanleyville, Belgian Congo, for work in the design of field experiments, biological assay and sample surveys, and for programming work on I.B.M. equipment—The Director General, I.N.E.A.C., 12 rue aux Laines, Brussels, Belgium.

TECHNICIAN (with some experience in clinical biochemistry and interested in biological work) IN THE ENDOCRINOLOGY LABORATORY—The Royal Marsden Hospital, Fulham Road, London, S.W.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Electrical Engineers. Report of the Council for presentation at the Annual General Meeting on the 23rd May, 1957. Pp. 18. (London: Institution of Electrical Engineers, 1957.) [225

Department of Scientific and Industrial Research. Hydraulics Research 1956: The Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research. Pp. vi+54+12 plates. (London: H.M. Stationery Office, 1957.) 4*s*. 6*d*. net. [225

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 969, Vol. 249 (16 May, 1957): The Complete Enumeration of Extreme Senary Forms. By E. S. Barnes. Pp. 461–506. 15*s*. 6*d*. No. 970, Vol. 249 (16 May, 1957): Electromagnetic Induction in Rotating Conductors. By A. Herzenberg and F. J. Lowes. Pp. 507–584. 26*s*. (London: Royal Society, 1957.) [225

Physics of Non-destructive Testing, with particular reference to some new aspects. Pp. iv+72. (Supplement No. 6 to the *British Journal of Applied Physics*.) (London: Institute of Physics, 1957.) 25*s*. [225

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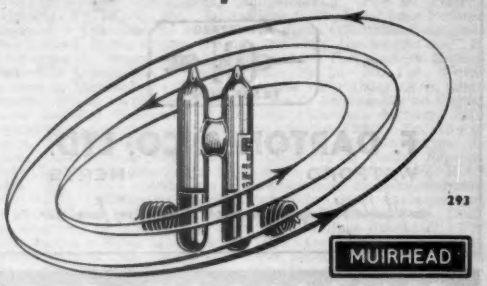

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